PRODUCT ENGINEERING

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Engineering for Tomorrow

"BUILDING the world of tomorrow" has been chosen as the theme of New York City's 1939 World's Fair. It is a good theme, particularly for architects and engineers whose work is to be used or enjoyed in the more or less distant future. The builders of structures and the designers of machines must be prepared to depart from tradition when tradition fails to meet the requirements that lie ahead.

Some one of the newspaper columnists pointed out recently that the general staff of any country always busies itself in studies of how to meet the problems of its most recent war. Also that the present neutrality debaters in Congress have worried about how to keep us out of the last war rather than any future war, which will be an entirely different war and will present quite different diplomatic problems.

The engineer cannot afford to spend as much time on post mortems as the lawyers and the soldiers can. Time is always stepping on his heels urging him to complete today his designs that are to be manufactured tomorrow and sold the day after. And these designs must be such that they will meet the new requirements of the day after tomorrow, requirements that may still be in the realms of conjecture.

Difficult as the task is, it is what the customer expects of the engineer. There is a machine tool buyer who is typical of this attitude. He is fortunate in that he has carte blanche in buying equipment so long as he can justify his purchases on an economic basis. In selecting one make of a certain type of tool he has done so solely because the designer of that make of tool has engineered it for the feed and speed conditions that may be required three, four or five years from now, rather than just today. He doesn't need or use those feeds and speeds now but he believes that he will need them long before the machine wears out, and he is striving to forestall as long as possible its yielding to obsolescence.

In designing products for tomorrow a word of warning against the freakish or unfamiliar in appearance is in order. We saw an industrial artist's model of an ideal automobile some five or six years ago. It looked outlandish then, in the extreme, but he was wise enough to set that model about five years ahead and to produce a series of transitional models for the intervening years, each one a little closer to the ultimate. Today we would accept most of the design features in his final model because they have been introduced to us gradually, one or two at a time.

Engineering for tomorrow, therefore, must rest on a nice balance between the most advanced performance factors, and appearance factors sufficiently restrained to avoid scaring off the prospective customer. Just one more of those characteristics demanded of the engineer for which he does not get all the credit that he should.

H. G. Weaver, directing head of General Motors Customer Research Staff. To his associates he is "Buck" — to millions of American motorists he is H. G. W.

The Philosophy of

CUSTOMER RESEARCH

An interview wherein H. G. Weaver of General Motors discusses the reasons for the existence of their Customer Research Staff, tells how it operates and what it has accomplished.

IN MODEST quarters on the eleventh floor of the General Motors Building in Detroit, a staff of about 45 men and women is busy constantly. The primary purpose of their activity is to keep a continual check on the ever changing tastes and desires of automobile buyers and users. Frequently work of this staff is referred to as the "Proving Ground of Public Opinion" because it is devoted to finding out the facts as regards the attitudes and opinions of motorists with reference to features of automobile design and merchandising procedure.

In an office full of charts and diagrams —behind a desk piled high with consumer correspondence, sits the directing head of General Motors Customer Research Staff, H. G. Weaver. To his associates he is "Buck." It takes only a few minutes conversation with him to be impressed with the fact that one is listening to a man possessing a rare combination of engineering facts and experiences, a philosophical reasoning that gets to the basic fundamentals and a vast knowledge of human reactions and prejudices. But his language is not that of an academic philosopher nor is his personal attitude one of aloofness. Far from it. His words are those of "the man in the street" and his conversation is frank, informal and congenial.

In answer to the question, "What is the main idea behind General Motors Customer Research?" Weaver was direct and to the point. "In a broad sense," he said, "it is the science or art of human understanding. It's really not a matter of sending out questionnaires or calling on people, but the broad idea of

providing the human facts so essential to the running of a modern industry.

"To put it briefly, Customer Research provides the means for:

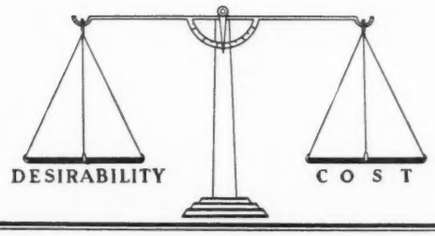
1. Finding out what the customer wants.

2. Designing products in line with his wants. (Consistent, of course, with sound engineering practices and cost limitations).

3. Describing products in the same language that he uses in expressing his wants.

4. Synchronizing merchandising tactics with current buying habits—as disclosed by research findings.

Answers to this question give a definite basis for determining the dollar value of specific design features as gaged by the buyer of the product



WHAT ARE THEY WORTH TO YOU ?

Additional equipment adds to the cost of the car and directly or indirectly this has its effect on the selling price. In other words the owner pays for the equipment and accessories whether they come on the car or whether he buys them extra.

From your personal standpoint there may be certain things you would like to see added to the standard equipment and, on the other hand, there may be other things that you had just as soon see left off.

By checking off your appraisal of each of the following items from the standpoint of what it is worth to you as a USER, you can guide the manufacturer in meeting your needs at the most favorable prices.

Here's An Easy Way To Do This:

First, read down the list and pick the feature that you consider MOST ESSENTIAL. - rate it whatever you think it is worth to you, - then rate the other items in comparison with it.

VERY LITTLE → → → → → → → → A WHOLE LOT										
Dash Compartment	0	$1	$5	$10	$15	$20	$25	$30	$40	$50	Dash Compartment
Adjustable Seats	0	1	5	10	15	20	25	30	40	50	Adjustable Seats
Ride Regulator	0	1	5	10	15	20	25	30	40	50	Ride Regulator
Oversize Balloons	0	1	5	10	15	20	25	30	40	50	Oversize Balloons
Safety Glass	0	1	5	10	15	20	25	30	40	50	Safety Glass
Radiator Shutters	0	1	5	10	15	20	25	30	40	50	Radiator Shutters
Syncro-Mesh	0	1	5	10	15	20	25	30	40	50	Syncro-Mesh
Free Wheeling	0	1	5	10	15	20	25	30	40	50	Free Wheeling
Automatic Clutch	0	1	5	10	15	20	25	30	40	50	Automatic Clutch
Automatic Starter	0	1	5	10	15	20	25	30	40	50	Automatic Starter
Automatic Choke	0	1	5	10	15	20	25	30	40	50	Automatic Choke
Floating Power	0	1	5	10	15	20	25	30	40	50	Floating Power
Hydraulic Brakes.	0	1	5	10	15	20	25	30	40	50	Hydraulic Brakes
"One Shot" Lubrication	0	1	5	10	15	20	25	30	40	50	"One Shot" Lubrication
_____?	0	1	5	10	15	20	25	30	40	50	_____?

"In other words there is nothing altruistic about General Motors Customer Research. We expect it to broaden our goodwill, we expect these benefits to be permanently assured because with the facts before us, there seems to be no reason why we cannot serve the public in a manner that will merit their continued and increasing patronage.

"For years past, business men have used the expression 'The customer is always right,' but it never occurred to anyone to try to find out what it was that the customer was right about."

"In American industry," he said, "We've always heard a lot of talk about 'breaking down sales resistance.' Customer Research approaches the problem from exactly the opposite viewpoint. In other words, our aim is to reduce sales resistance right at the start, in one place, under controlled conditions, namely, back in the engineering department. This avoids multiplying sales effort. The selling job is made easier since the needs and desires of the consumer are definitely reckoned with in the design and manufacture of the product and the salesman is no longer depended upon to talk the buyer out of wanting what he already wants and then talk him into wanting something he doesn't want.

"To carry out this idea of designing for consumer acceptance, as against designing a product that meets sales resistance, one must know, before the product is designed, what the buyer wants. And the only way this can be accomplished is by asking the consumer through the medium of both questionnaires and personal interviews.

"We in Customer Research do this through personal interviews and direct mail questionnaires, both methods having advantages peculiar to themselves. The method used is determined by the kind of reactions we want to get. Naturally the personal interview is best for questions on which we want spontaneous answers—but since most of our questions concern features of design and generally require a mental weighing of pros and cons, our major surveys are conducted through the mails. This requires an effective questionnaire that will attract the motorist enough so that he will read it, get interested in it, fill in the information desired and return it.

"The development of an effective questionnaire is not an easy job. It is an individualistic job, something like laying out the contour of a truly artistic automobile. Before designing a questionnaire we ask ourselves these questions:

1. What do we want to find out?

2. Why do we want to find it out?

3. What can we do about it after we find out?

"When we have the answers we design the questionnaire with a view to making

it interesting and informative to the motorist, and also efficient from the standpoint of keeping it in a form that is best for tabulation purposes."

A successfully operating customer research organization will find out what the customer wants, thereby enabling the engineering department to develop a design, consistent with sound engineering, so that the product will be the way the customer wants it. And by the same token, the advertising, sales and service activities will be able to proceed with a specific knowledge of customer psychology and buying habits. Under these conditions, design, sales and service procedures can all be coordinated to tune in with what the customer wants.

How the Designer Profits

Why is it necessary for the engineering design department to have available customer research data that has been gathered through organized effort? In answer to this question, it is impossible, except in a few cases, for the designer of mass production products to keep his finger on the pulse of consumer wants. Not only is he too far removed from the users of his products, but the tastes, desires and buying habits of the user are always changing and at a fast rate. Educational programs, advertising campaigns, increased reading and the radio have all contributed to making swift the changes in modes of living, consumer wants and concepts of relative values. New desires sometimes become rooted even before one is conscious that a change is taking place.

One of the ever present stumbling blocks to product improvement is the cost factor. Under the usual conditions, engineering, production and sales departments will wrangle for many hours as to whether or not the prospect will pay the added cost of a suggested improvement. Such a conference is merely a battle of opinions with little or no data to back them up. General Motors Customers Research Staff gets the facts, asks the automobile user to indicate how much a given feature is worth to him in dollars.

It is not to be assumed that only those features that receive a preponderant vote are of significance, nor is it expected that every suggestion will be acted on. As explained by Mr. Weaver:

"Naturally, we cannot expect the public to design our cars for us. So the main thing we're after is to get a measure of what we might call the boundary lines of public acceptance. In other words, which of the things that we have on the fire in our research laboratories and engineering departments would be the most logical to push forward into production?

What the Surveys Reveal

"To answer this question, each year General Motors has been mailing out approximately 2,000,000 questionnaires to owners of all makes of cars. We get back a lot of crazy suggestions and we get back a good many sensible ones. As long ago as 1931, for example, we were getting requests for such things as solid steel tops, built-in tire carriers, independent springing, automatic chokes, wider front seats, arm rests for drivers, improvements in ventilation, and many similar suggestions that have since been incorporated in automobiles. The motorists suggesting such things were few in number at first—straws in the wind so to speak—but by keeping continually at it through our surveys we were able to provide our engineers with periodic reports showing the trend of public thinking."

Another valuable feature of customer research is that the prospective purchasers like to be consulted as to their likes and dislikes in the design of a product. When they see in the product even only one design feature which they suggested or for which they expressed preference, they naturally are impressed favorably. It gives rise to a feeling that the product is being designed to their specifications; being made to their order. Thus sales can be made more easily and at less expense. It is then unnecessary to first break down sales resistance and then build up an acceptance for something that the customer does not want. Customer acceptance has already been insured by the results of customer research.

Much of the success of a questionnaire type of survey depends on the preparation of the questionnaire. As pointed out by Mr. Weaver, there are at least three types of questions which a questionnaire should not be expected to answer. Thus:

1. Some questions are important, but it is well nigh impossible to get the answers.
2. Others are interesting and may satisfy a healthy curiosity—but are not suggestive of any direct course of action.
3. Still others are significant as bearing on an individual transaction—or a limited group of transactions, but the answers are practically worthless in terms of broad general averages.

A Few Ground Rules on Asking Questions

1. We cannot be satisfied with getting the question merely so it can be understood; it must be designed so carefully that it simply can't be misunderstood.
2. In dealing with technical features we should emphasize not the mechanical construction but the effects attained through such construction.
3. We must observe the rules of good etiquette and guard against ballyhoo and insincerity.
4. The informal conversational style is preferable except in instances where it works at cross purposes to securing the best scientific results.

General Motors has been mailing out about 2,000,000 questionnaires annually to owners of all makes of cars, to find out what the customer wants

5. Among other things we must employ phraseology that is in common usage with the user of the product, even though such phraseology may not represent the best scientific terminology.

6. "Give and Get"—We must remember that we are asking the consumer to do us a favor. We should observe the principle of "Give and Get" and, since the kind of people to whom we are catering can't be bought with any pecuniary means within our reach, our giving must be in the nature of information or mental satisfaction.

7. Questions regarding any series of items, the answers to which are to be compiled on a relative basis, should all be asked the same way.

8. Needless to say, every effort should be put forth to guard against anything that would create a biased attitude in the mind of the buyer.

This necessitates a careful scrutiny, not only of the individual question, but of the questions preceding it. The questions preceding may be all right within themselves, but they may have to be changed or located differently in order to avoid building a biased atmosphere with regard to a subsequent question.

Exact Results Not Needed

There are some exceptions to this rule. For example, the General Motors Customer Research Staff consider it desirable and proper to deliberately bring up the question of "economy" incident to the questions on speed.

9. The arrangement or continuity of questions should be such as to facilitate the consumer's "flow of thought." People have difficulty in shifting their minds back and forth from one thing to another.

10. When it is necessary or expedient to ask a biased or a leading question, another question containing the opposite bias or lead should be added.

11. To get maximum value out of consumer research findings it is necessary, as previously pointed out, to ask questions the same way year after year —and as a corollary to this, no pains should be spared to get the questions right—right from the start.

In the interest of sound interpretation, the visualization of the final compilations as well as the uses to which they are to be put should always precede the making of any consumer survey.

It seems needless to stress the importance of interpretation. This problem of interpretation is important in all forms and applications of consumer research work, but in the opinion of Mr. Weaver, it is of far greater importance and surrounded by greater difficulties in the automobile field than in any other because of the complexities of the product and the inter-relation or inter-dependence of the various features of design and performance in an automobile.

While it is not to be hoped that consumer research can ever be reduced to an exact science, the failure to obtain scientific exactitudes, however, does not always vitiate the value of the results.

Even though it were possible to get results that were accurate down to the last decimal place, it is difficult to conceive how the action based on such results could ever be reduced to such a hair-splitting basis. For example, in the case of a certain feature, it doesn't make very much difference whether the consumer vote indicates 75 per cent preference or 95 per cent preference—the action taken on the basis of either finding, would at best be more or less arbitrary and would likely be the same as both findings give a positive indication.

Value of Annual Surveys

And here is another important point: The principal value of the findings will, in many instances, lie not so much in any one isolated figure but in relative comparisons between different figures—not only as between different items but on the results obtained from year to year. For example, in the General Motors "Census of Consumer Preferences," the staff tried out a number of ways of asking the questions, adopted what proved to be the best technique, and then stuck to it without variation.

Thus, the figures must be kept on a comparable basis year after year. So it doesn't make much difference whether the indices are intrinsically correct. It doesn't even make much difference whether the "answers" represented a fair sample of how the "non-answers" might have voted. For all practical purposes the annual results are comparable.

Many factors in addition to those discussed here enter into the problem of making questionnaire surveys. The degree to which the data are to be broken down, the number of samples required, follow ups and correspondence with selected individuals are some of the other things that must be planned and decided.

The broadening sphere of knowledge required of designing engineers is strikingly indicated in the statement by Weaver when he said:

"Progress in future designs comes not alone out of the research laboratories and engineering textbooks, but also through a better understanding of the human factor. The operation of the controls must conform to the most natural movements of the feet, legs and arms. The design of a little thing like a foot throttle must not only take into account the strength of the materials and the laws governing mechanical links and levers but also must consider the physiology of the leg muscles and the possibility of nerve strain in long distance travel.

"Thus it is necessary for the designer to look beyond the engineering handbooks and interest himself in such things as physiology, psychology and neurology."

A complete record of all replies is maintained, indexed according to geographical distribution, make of car owned, and under numerous other heads

Product Development

Dynagraph

An instrument, known as a Dynagraph, which clamps onto a reciprocating rod and translates the distortion of the rod into a graphic record of the instantaneous loads on the rod throughout its entire stroke, has recently been developed by the Westinghouse Electric & Manufacturing Company. Primarily designed for use on the polished rods of oil-well pumping machinery, the instrument is entirely self-contained and entirely mechanical in operation, no electric or hydraulic parts being used. Small in size and light in weight, it multiplies the rod distortion some 400 times and records loads up to 25,000 lb. on a 1¼-in. rod with 98 per cent accuracy.

Design of the instrument was influenced by the need for a device of this type which could be handled by one man and would not be affected by temperature changes, electric power fluctuations, or bending of the rod.

As shown in Fig. 1, the instrument consists essentially of two clamping assemblies, a stylus-operating linkage, and a recording cylinder similar to that used on a gas-engine indicator. Referring to Fig. 2, the two clamping assemblies *A* and *B* are attached to the rod *C*. Load changes on the rod result in a stretch or strain between *A* and *B*. When *A* moves away from *B*, the struts *L*, *M*, *N*, *O*, produce a rotation of the member *F*, resulting in a vertical movement of the channel *G*. This movement is about ten times the extension between *A* and *B*. Mounted on the channel *G* is a thumbscrew assembly *D*. From it, a connecting rod *H* runs to the stylus-operating assembly *J*. The recording stylus *E* moves horizontally some 40 times the vertical movement of the channel *G* and, as a result, the displacement of the

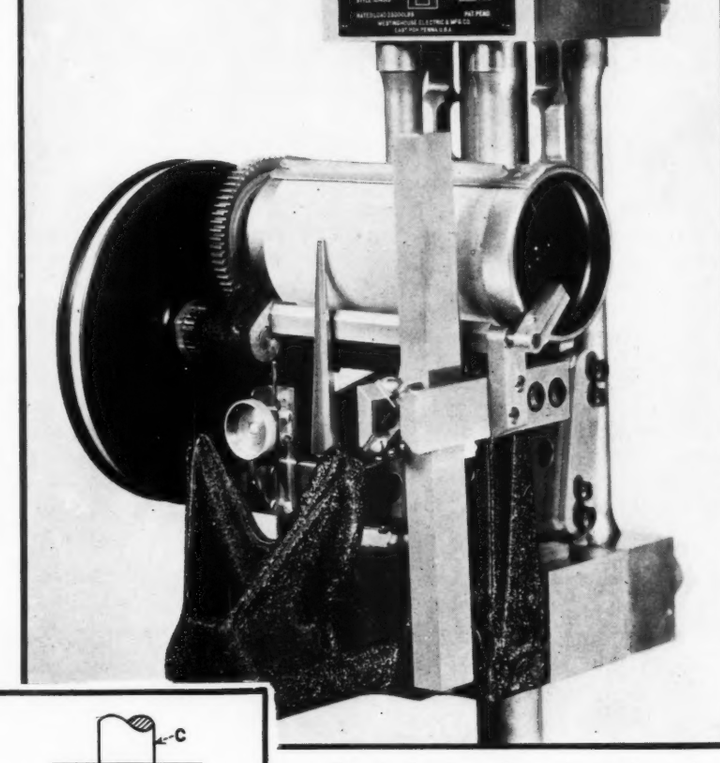


Fig. 1—Load on the reciprocating rod to which it is clamped is recorded by this compact mechanical instrument, called a Dynagraph

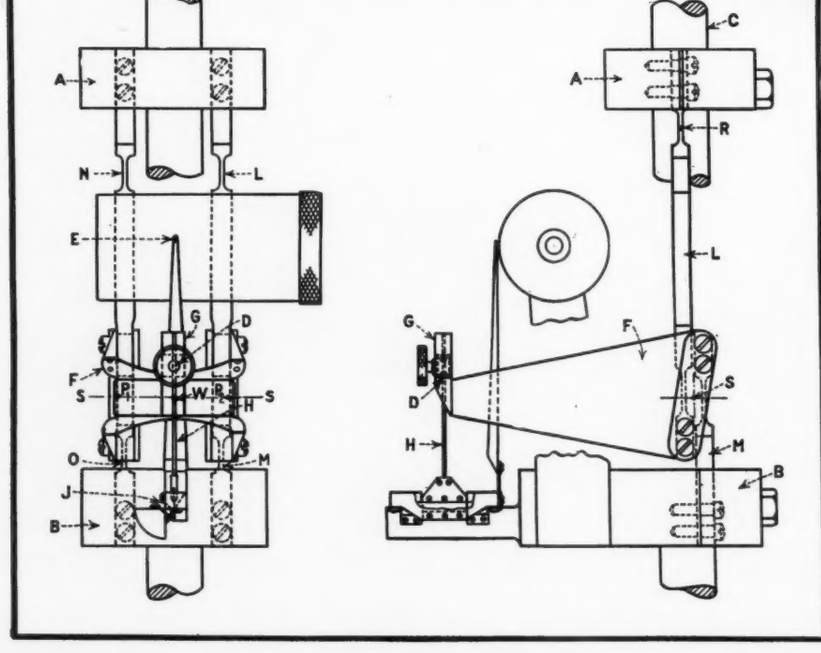


Fig. 2—Through the system of linkages detailed in this sketch, the Dynagraph multiplies the extension of the rod to which it is clamped some 400 times and eliminates errors due to bending of the rod

stylus is approximately 400 times the extension between *A* and *B* on the rod.

Referring again to Fig. 1, it will be noticed that there are four columns surrounding the struts. There is a clearance between them and the clamping assembly *A*. Hence, when the instrument is being used on a tension test, they do not enter into the operation. On compression tests, however, the load is applied on these four columns and the instrument records the strain in them.

A feature of the design is that, through proper location of the necked-down portions of the struts and of the clamping points of the springs in assembly *J*, a straight-line calibration curve is obtained. This permits the load record to be interpreted by using a multiplication factor instead of referring to a calibration curve.

The instrument is not affected materially by bending of the rod under test. In fact the bending error is less than one per cent of the full-scale deflection for bending stresses as high as 15,000 lb. per sq. in. on a 1¼-in. rod. This elimination of bending error was accomplished by the manner in which the struts and the connecting rod *H* were designed and positioned.

Bending of the rod in a plane parallel to the axis of the recording cylinder, causing rotation of the clamp *A* clockwise, will lower point P_2 and raise point P_1 by an equal amount. Thus the elevation of the point *W* does not change, the stylus *E* does not move, and therefore no error occurs.

Bending of the rod in a plane at right angles to the axis of the recording cylinder, causing rotation of the clamp *A* clockwise, bends the necked-down portions of the struts at the points *R* and *S* but does not rotate the member *F* with respect to the clamp *B*; hence no error results.

The natural frequency of the instrument is about 80 cycles per sec., and consequently load changes up to 20 cycles per sec. can be accurately recorded.

Metallic Bellows in Gas Analyzer

In the new Hays Orsatomat, a flue gas sample can be analyzed in 20 sec., the results being indicated on a scale by a pointer operated by a metallic bellows and linkage. The orsatomat consists of a rotatable analyzing body which contains the measuring and absorption chambers charged with mercury and an absorbing chemical; and aspirator tube and necessary rubber tubing; and the metallic bellows and linkage for moving the pointer, all mounted in a pressed steel case.

The operator aspirates the sample of the gas into the instrument while it is in the sampling position as in Fig. 1. Shown with the back cover removed, and the rod 1 in the up position. The automatic valve 6 allows the gas sample to by-pass so that it is always measured at atmospheric pressure. The rod 1 is pushed down to the analyzing position, sealing the automatic valve 6 and rotating the analyzing body 2, causing the mercury in the analyzing body to flow to a new position. The liquid absorbing chemical floats on top of the mercury and the gas sample is displaced by the movement of the mercury and chemical, from the measuring chamber 4 into the absorption chamber 7, where it is forced into intimate contact with a steel wool saturated with the absorbing chemical. The absorption of the CO_2 causes a shrinkage in the volume of the sample creating a partial vacuum which causes a movement of the metallic bellows 11 in Fig. 2. The movement is trasmitted to a pointer which indicates on the scale the per cent CO_2 absorbed.

Designed for Rapid Spring-Load Testing

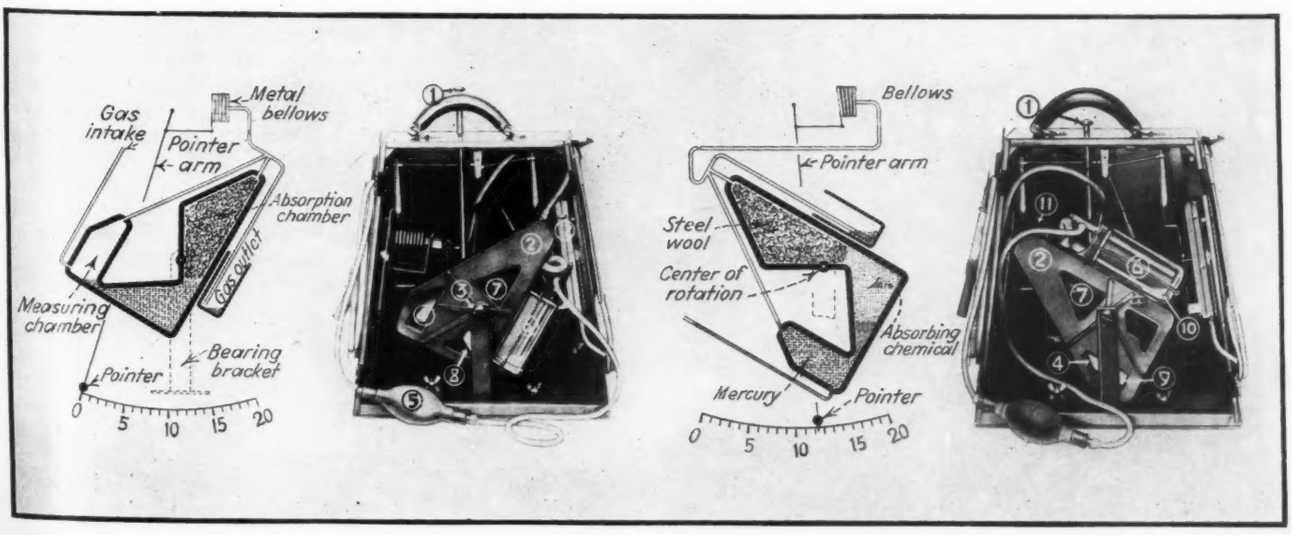
For quickly and accurately testing the strength of springs, the spring checker manufactured by the Link Engineering & Manufacturing Company provides direct reading of the length of the spring under test and of the load upon it.

The load is provided by a spring-unit incorporated in the base of the device and made up of a calibrated load spring and dial mechanism. Calibration of the spring unit within very close limits is made possible by the use of two calibration heads; a fixed head at the top end and an adjustable head at the lower end of the load spring. The weighing table and top are mounted on a pilot sleeve which operates vertically along the axis of a pilot shaft located perpendicular to the center of the base. Ball bearings between the pilot sleeve and the pilot shaft eliminate friction and act as guides to assure straight-line operation.

The spring-unit is so designed that when the maximum capacity of the dial is reached, the spring is only partially compressed to its full working strength and cannot be further stressed because the pilot sleeve then bears solidly on a stop shoulder provided by the top of the

Fig. 1—Gas analyzer, in sampling position, with back cover removed to show the operating mechanism

Fig. 2—Orsatomat in analyzing position, showing arrangement of absorption chamber, bellows and scale



threaded boss which is a part of the base casting.

With this arrangement the weighing table acts freely on the load spring, and the load is indicated by the dial in the base, which is connected to the weighing table by an accurately cut rack-and-pinion.

The length of the spring under test is indicated by a height-scale attached to the weighing table and extending upward past a hairline even with the top of the spring.

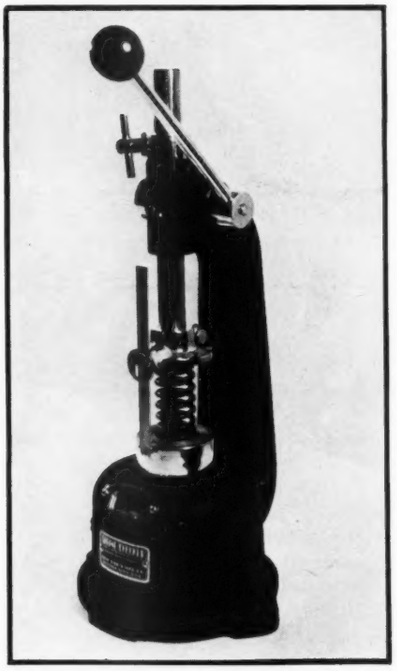
Since each load spring is carefully calibrated and since it cannot be overstressed, there can be no variation in accuracy unless friction occurs in the movement of the weighing table. This possibility is avoided through the use of the ball bearings between the pilot shaft and the pilot sleeve, as shown in the accompanying sketch.

Because of the accurate straight-line motion of the weighing table, it is reported that the spring undergoing test need not be accurately positioned or centered. Instead, it is merely placed on the weighing table and the handle pulled down until the height-scale indicates the desired compressed length, and then the load is read on the dial.

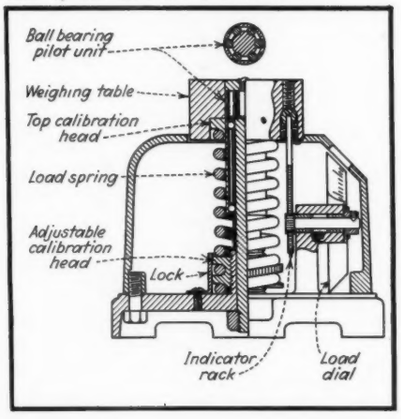
When a number of similar springs are to be tested, the stop at the top of the loading plunger is clamped at the proper height indicated by the scale, as determined by a trial test of a spring, and then it is merely necessary to pull the handle to a stop to read the load on the spring.

The lever on which the handle is mounted has an octagonal socket, like a socket wrench, which is held against a square boss by a spring, so that eight-point adjustment for different length springs is provided.

The spring tester is manufactured in two sizes: one of 50-lb. capacity, calibrated in ¼-lb. units; the other of 250-lb. capacity calibrated in 1-lb. units.



Direct reading of the length of spring under test and of the load upon it is provided by this convenient spring tester. Details of the unit are shown below



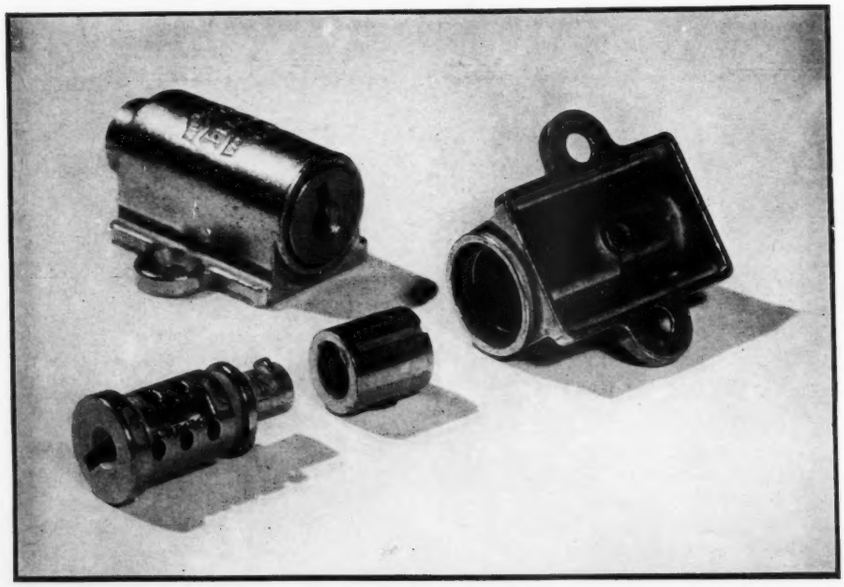
Die-Cast Lock

Requiring no finishing operations other than that of plating before assembly, the casing, cylinder and bolt of the sash tumbler lock manufactured by the E. T. Fraim Lock Company, are made entirely by die-casting.

The casing has an integral key which engages the cast keyway in the bolt. The cylinder in which the five disk-tumblers and springs are retained, has a projection at the small end, operating in a spiral slot within the bolt. The whole assembly is held together by means of a drive pin entering a hole in the bottom of the casing and engaging a slot in the periphery of the cylinder.

Although designed as a sash lock, its construction is such as to permit its use in a wide variety of applications. Measuring 1-3/8x1-9/16x7/8 in., it is made in two styles. Style A and Style B are similar except that the former is provided with two ferrules for locking windows both closed and open and Style B is provided with a flat strike plate for locking wardrobes, cupboards, lockers, etc. With the five disk-tumbler construction, 250 key changes are possible.

Die-casting the parts of this tumbler lock eliminates all finishing operations prior to assembly except that of brass-plating



Random Jottings About New Developments

In order to equalize the load carried by each roller of roller conveyers used for heavy materials-handling applications, the Mathews Conveyer Company, Elwood City, Pa., has developed a shock-absorbing, resiliently mounted roller conveyer. With the new design, the mounting for each roller is carried on a heavy coil spring. The resiliency thereby provided causes each roller to carry its proportinate share of the load, minimizes high peak loads on the bearings of any one roller, and reduces the coefficient of friction used in calculating the effort required to move the load along the conveyer.

* * *

Because of the better wearing qualities of stainless steel as compared with gold, men's wristwatches and straps are being made of stainless. Not only is the material non-magnetic and tarnish-resistant, but also less expensive.

WORKING STRESSES

for Members Subjected to Compound Loads

JOSEPH MARIN, *Rutgers University*

Comparing designs based on various theories of failure under combined loading shows that the resulting differences in size of parts may sometimes be appreciable

WHEN DESIGNING a machine part that will be subjected to simple tension, the dimensions are determined after establishing a working stress based on a proof stress, that is, a yield point stress S for ductile materials, or an ultimate stress S for brittle materials.

However, in the design of elements, such as shafts and helical springs, that are subjected to twisting and bending forces, dimensions are assigned after considering the effects of the combined stresses. The components of stress acting at a point in a machine member are usually possible to determine. These components can be represented by the principal stresses S_1 and S_2 acting at right angles to each other on planes free from shearing stresses. In this article only biaxial stresses will be considered, that is, stresses in one plane.

When stresses are combined, failure is influenced by the mutual effect of one stress on the other, and to define a theory of failure a hypothesis must be assumed as a basis. A number of theories have been presented. (See "Failure Theories for Materials Subjected to Combined Stresses," J. Marin, *Trans.* A.S.C.E., 1936). The main theories that have been used are the stress and the shear theories.

The stress theory is based on the assumption that failure is not influenced by the presence of one stress acting at right angles to another. For a material with the same strength in tension and in compression, the condition for failure according to the stress theory is such that either the principal stress S_1 or the principal stress S_2 has reached a limiting value equal to a constant value S representing the proof stress, yield point or the ultimate stress in tension or compression for the material. This relation at failure may be expressed algebraically by the equation

$$S_1 = \pm S, \text{ or } S_2 = \pm S \quad (1)$$

in which the plus sign denotes tension and the minus sign compression.

The shear theory is based on the concept that where combined stress exists failure occurs when the induced shear stress caused by the combined load equals the induced shear stress at failure in simple tension. In this theory, however, a necessary assumption is that values of S in tension and compression be equal. With S again representing the yield point, proof stress or ultimate stress in tension or compression, the principal stress S_1, to produce failure for a given value of the other principal stress S_2, or vice versa, may be stated algebraically:

When S_1 and S_2 are both tension
$+ S_1 = + S$, or $+ S_2 = + S$ (2)

When S_1 and S_2 are both compression
$- S_1 = - S$, or $- S_2 = - S$ (2′)

When S_1 is tension and S_2 is compression
$S_1 - S_2 = \pm S$ (2″)

When S_1 is compression and S_2 is tension
$S_2 - S_1 = \pm S$ (2‴)

The shear energy theory which is

FIG. 1

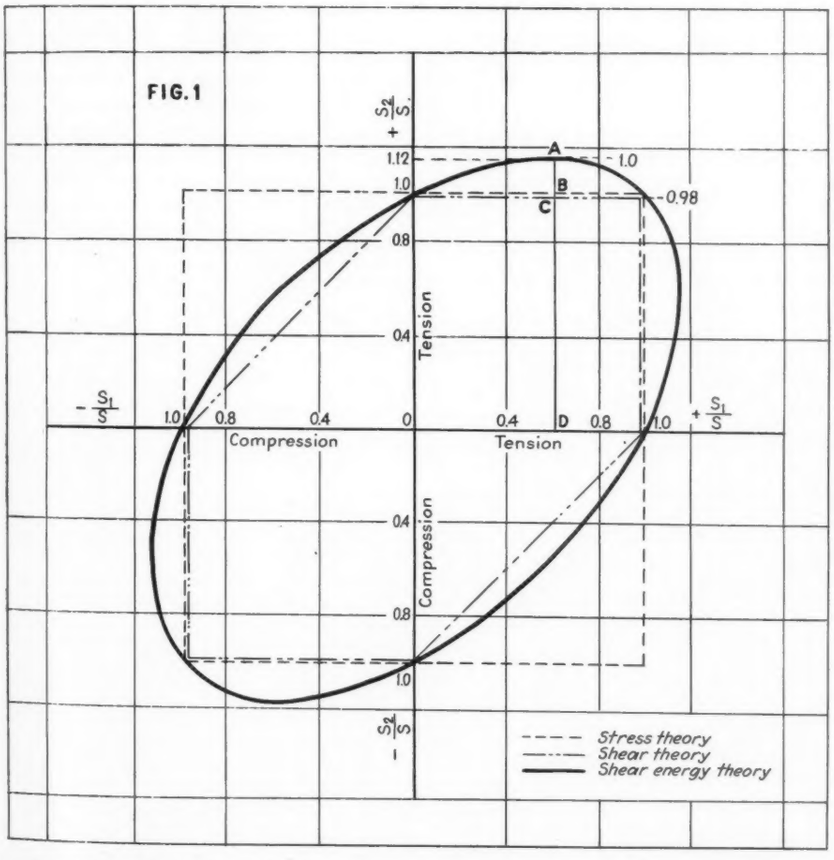


Fig. 1—Failure stresses obtained from three different theories for any combination of principal tension or compression stresses, based on the ratio of the limiting simple tensile strength to the principal stresses acting simultaneously along perpendicular axes. As an example; for a tensile principal stress along one axis equal to one-half the ultimate tensile strength of the material, another tensile principal acting at right angles to the first will cause failure at a value equal to 0.98, 1.00 and 1.12 times the ultimate tensile strength according to the shear theory, stress theory and shear energy theory respectively

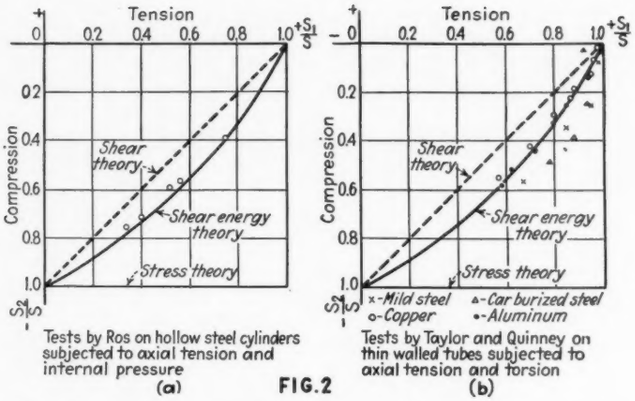


Fig. 2—Data from tests show agreement with the shear energy theory of failure. (a) Tests by Ros on hollow-steel cylinders. (b) Tests by Taylor and Quinney on thin walled tubes

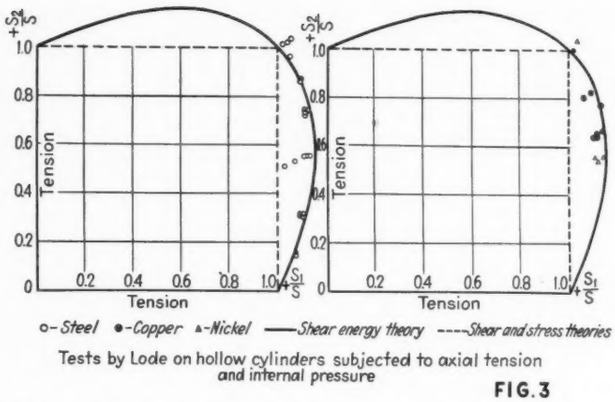


Fig. 3—Tests by Lode on hollow cylinders show further agreement with shear energy theory

recommended because of its agreement with test results, assumes that failure occurs when the energy of distortion equals the shear or distortion energy at failure in simple tension. In working with this theory it is necessary for the stress S to be the proof stress or the yield point, since the theory is based on Hooke's Law. In addition, this theory assumes that the value of S in tension or compression be equal. For a specific value of the principal stress S_2 the value of the other principal stress S_1 that will produce failure is by this theory defined by the equation,

$$S_1^2 - S_1 S_2 + S_2^2 = S^2 \qquad (3)$$

The stress ratios S_1/S and S_2/S obtained from Equations (1), (2), and (3) by dividing each side of these equations by S are shown in Fig. 1 for graphically comparing the relation of the three theories.

A comparison between theories and test results for experiments made previous to 1928 shows that there is no consistent agreement between tests and any one theory. (See "Failure Theories for Materials Subjected to Combined Stresses," J. Marin, *Trans.* A.S.C.E., 1936). This may be caused by errors involved in testing technique or uncertainties in defining failure.

More reliable recent test results show, however, that for ductile materials the shear energy theory is in good agreement with test results. For brittle materials such as cast iron recent experiments show that the stress theory is suitable. These tests are compared in Figs. 2, 3, and 4 with the theories discussed. Tests by Ros and Eichinger (See "Versuche Zur Klarung der Frage der Bruchgefahr," Eigenossische Material Prufungsanstalt an der E. T. H. in Zurich, *Diskusionsbericht. No. 28-1928 and Nr. 34-1929*) plotted in Fig. 2*a* were made on hollow steel cylinders subjected to axial tension and internal pressure.

Taylor and Quinney (See "Plastic Distortion of Metals," *Phil. Trans.*, Royal Soc. of London, Series A. Vol. 23, 1931, p. 323) made tests, results of which are plotted in Fig. 2*b*, on thin walled tubes of aluminum, copper, mild steel and decarburized iron subjected to axial tension and torsion.

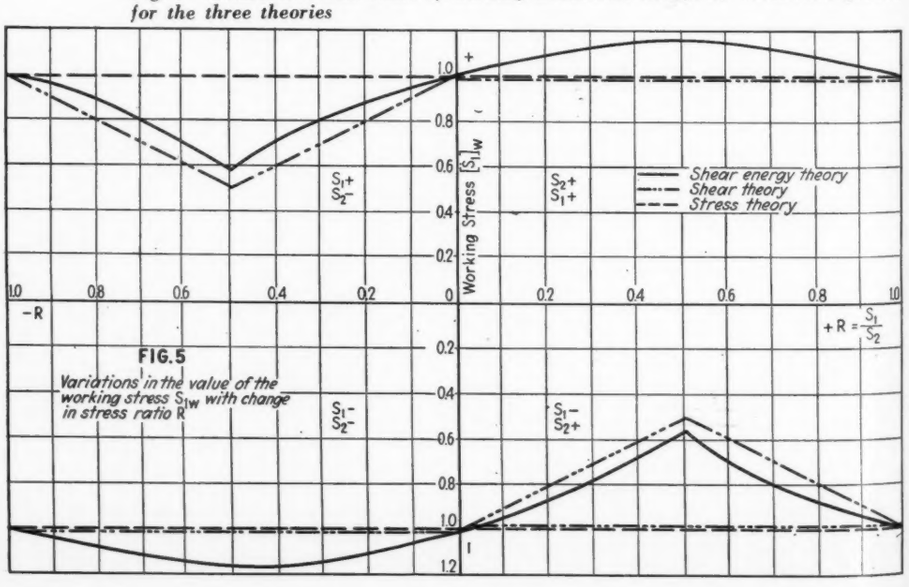
Hollow steel, copper, and nickel cylinders subjected to axial tension and internal pressure were tested by Lode (See "Der Einfluss der Mittleren Hauptspannung auf des Fliessen der Metalle," *V. D.I. Forshungsarbeiten*, Heft 303, 1928.) In Fig. 3 data taken from Lode's tests are plotted. All these tests show a good agreement with the shear energy theory.

For a brittle material such as cast iron there are only a few test results; those of Ros and Eichinger (See "Versuche Zur Klarung der Frage der Bruchgefahr," Eigenossische Material Prufungsanstalt an der E. T. H. in Zurich, *Diskusionsbericht, Nr. 28-1928 and Nr. 34-1929*) on cylinders subjected to axial tension and internal pressure, and also tests by Cook and Robertson on cylinders subjected to internal pressure (See "The Strength of Thick Hollow Cylinders under Internal Pressure," *Engineering*, Vol. 92). These test results as shown in Fig. 4 are approximately in agreement with the stress theory.

The determination of working stresses for a brittle material subjected to combined stresses does not offer any difficulty since it is only necessary to consider the maximum principal stress and to divide this stress value by an appropriate factor of safety. The remainder of this discussion will therefore refer to ductile materials and the shear energy theory.

Considering the principal stress S_1 to be greater than S_2 the value of the allowable stress S_1 is determined from Equation (3) by dividing the stress S by

Fig. 5—Variations in the value of working stress with change of stress ratio plotted for the three theories



an appropriate factor of safety n such that $S/n = S_w$. The value of the working stress S_{1w} is then defined by solving Equation (3) for S_1 or

$$S_{1w} = \frac{S_w}{\sqrt{1-R+R^2}}$$

where $R = S_2/S_1$

Variations in the value of the working stress S_{1w} with change in stress ratio R are shown in Fig. 5. The variation is also shown for the stress and shear theories for purposes of comparison. This diagram can conveniently be used for determining the working stress value. Thus, for a given loading the critical stress ratio R can be determined and the corresponding stress S_{1w} selected from the diagram. It is of significance, however, to determine what differences occur in the final design by the use of the shear or stress theory as compared to the shear energy theory.

Two illustrations will be used to show that there is an appreciable difference in the size of machine members designed by the shear and by the shear energy theories. The shear theory is the one used in the 1927 A.S.M.E. "Code for the Design of Transmission Shafting," and is usually used by machine designers.

Example 1—Shaft subjected to bending and twisting moments.

For a shaft subjected to twisting and bending moments the principal stresses in terms of the loads are:

$$S_1 = S_2 = \frac{16}{\pi d^3}\left[M \pm \sqrt{M^2+T^2}\right] \qquad (A)$$

M = the bending moment in inch-pounds,
T = the twisting moment in inch-pounds, and
d = the diameter of the shaft in inches.

Substituting the values of S_1 and S_2 from Equation (A) in Equations (1), (2) and (3) and placing S_w for S, and also placing R for M/T, the diameter required by each of the stress, shear and shear energy theories is respectively:

$$d_1 = \left(\frac{16T}{\pi S_w}\right)^{\frac{1}{3}}\left[R+\sqrt{R^2+1}\right]^{\frac{1}{3}} \qquad (B)$$

$$d_2 = \left(\frac{32T}{\pi S_w}\right)^{\frac{1}{3}}\left[\sqrt{R^2+1}\right]^{\frac{1}{3}} \qquad (B')$$

$$d_3 = \left(\frac{16T}{\pi S_w}\right)^{\frac{1}{3}}\left[\sqrt{4R^2+3}\right]^{\frac{1}{3}} \qquad (B'')$$

The variation of the diameter with the load ratio $R = M/T$ is shown in Fig. 6 for each of these theories. The maximum difference between the theories occurs for $R = 0$, that is for the condition of simple torsion, and for which the diameter of the shaft as calculated by the shear theory is 26 per cent larger than the diameter as calculated by the stress theory, the latter theory being the recommended one.

Example 2—High-pressure piping subjected to internal pressure.

For a thick pipe of internal radius a and an external radius b, subjected to an internal pressure p, the required thickness for each of the stress, shear and shear energy theories is defined by

$$L_1 = \frac{R^2+1}{1-R^2},\quad L_2 = \frac{2}{1-R^2},\quad L_3 = \frac{\sqrt{3+R^4}}{1-R^2} \qquad (C)$$

where $R = \frac{a}{b}$, $\qquad L = \frac{S_w}{p}$

The variation in the thickness t, which equals $b\ (1-R)$, with the pressure p is shown in Fig. 7 for each theory. The differences here are also appreciable.

There are many other groups of machine members subjected to combined stresses which show appreciable differences in design depending upon the theory used. The writer recommends the use of the shear energy theory based on the above comparison with test results and the fact that the shear energy theory is just as easily applied. It should be noted however that there is need for further experimental work in the study of materials subjected to combined stresses.

The discussion presented here is applicable only to materials that have the same strength in tension and compression. Evidently for materials such as cast iron wherein there is a big difference between the tensile and compressive strengths, the above analysis does not apply.

Also stated in the beginning of the article, the discussion can be applied only to machine members subjected to loads that create stresses lying in the same plane. Thus, it must be possible to resolve all the principal stresses into two mutually perpendicular components.

Fig. 4—Results of tests by Ros and by Cook and Robertson follow the stress theory for cast iron cylinders

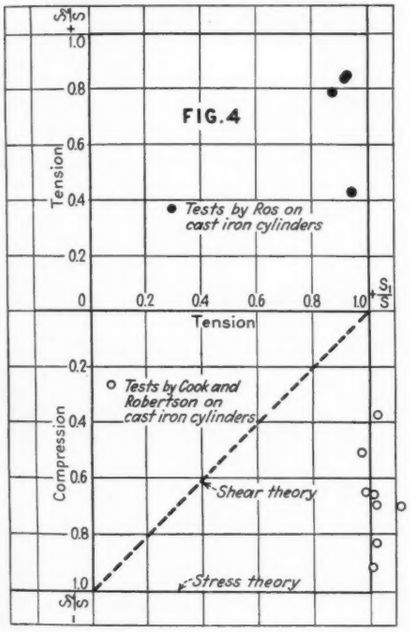


Fig. 6—Shaft diameter as calculated by different theories show varying results

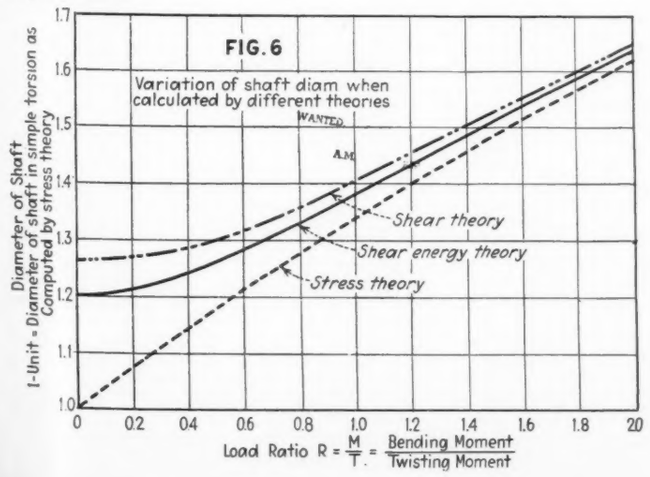


FIG.6
Variation of shaft diam when calculated by different theories
WANTED
A.M.
Shear theory
Shear energy theory
Stress theory
Diameter of Shaft / Diameter of shaft in simple torsion as Computed by stress theory = 1-Unit
Load Ratio R = M/T = Bending Moment / Twisting Moment

Fig. 7—Differences in wall thickness ratios of thick cylinders show how specific formula used may affect design

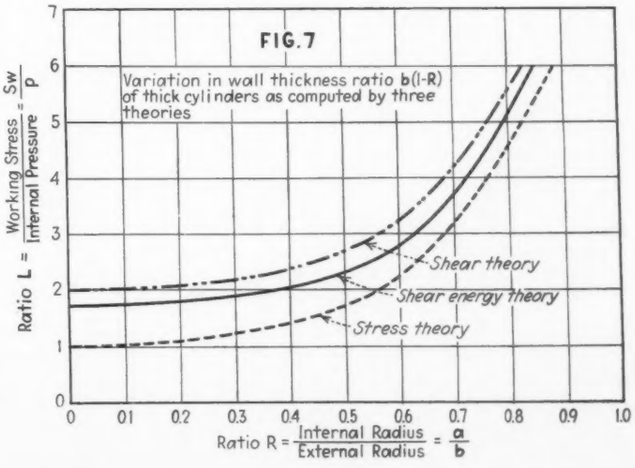
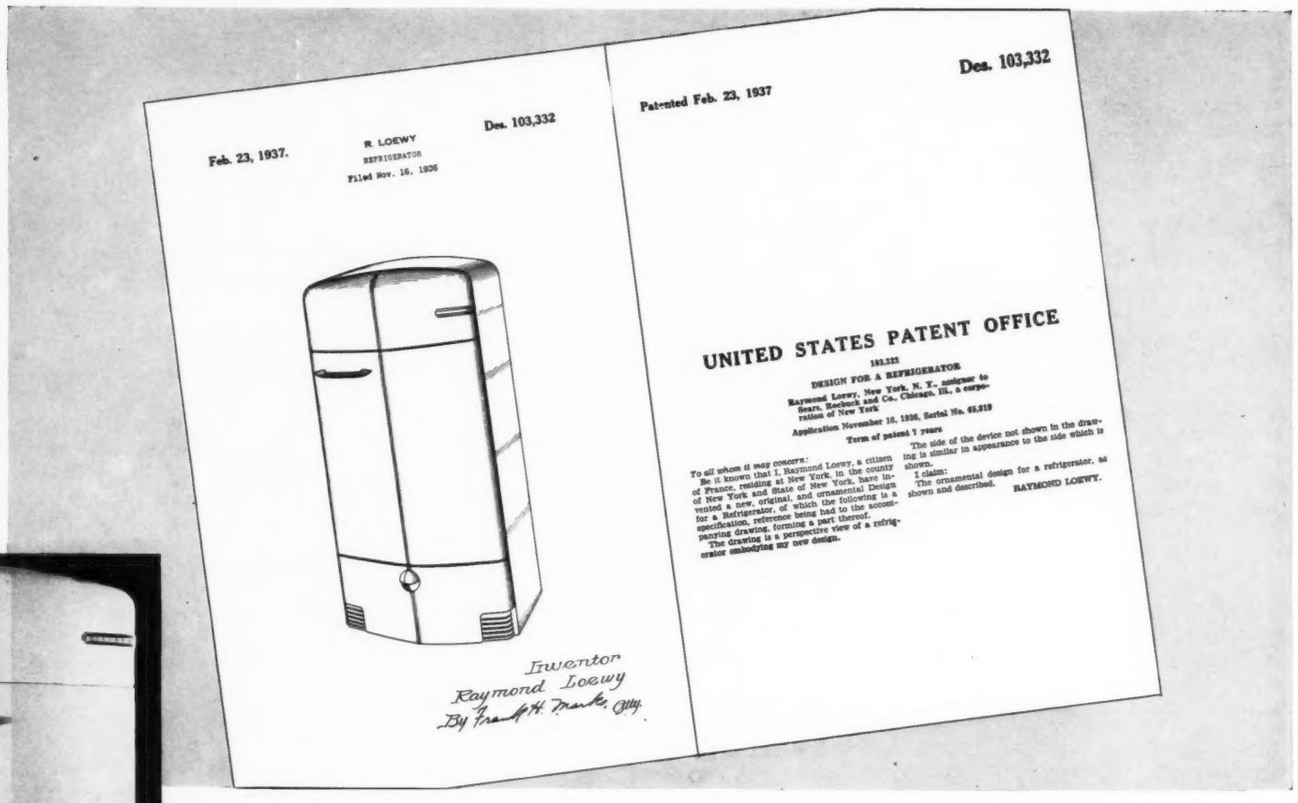


FIG.7
Variation in wall thickness ratio b(1-R) of thick cylinders as computed by three theories
Shear theory
Shear energy theory
Stress theory
Ratio L = Working Stress / Internal Pressure = Sw/p
Ratio R = Internal Radius / External Radius = a/b



Feb. 23, 1937. R. LOEWY REFRIGERATOR Filed Nov. 16, 1936 Des. 103,332

Inventor Raymond Loewy By Frank H. Manke, Atty.

Patented Feb. 23, 1937 Des. 103,332

UNITED STATES PATENT OFFICE

103,332

DESIGN FOR A REFRIGERATOR

Raymond Loewy, New York, N. Y., assignor to Sears, Roebuck and Co., Chicago, Ill., a corporation of New York

Application November 16, 1936, Serial No. 46,819

Term of patent 7 years

To all whom it may concern:

Be it known that I, Raymond Loewy, a citizen of France, residing at New York, in the county of New York and State of New York, have invented a new, original, and ornamental Design for a Refrigerator, of which the following is a specification, reference being had to the accompanying drawing, forming a part thereof.

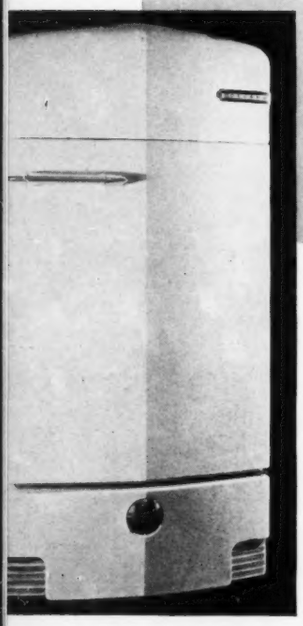
The drawing is a perspective view of a refrigerator embodying my new design.

The side of the device not shown in the drawing is similar in appearance to the side which is shown.

I claim:

The ornamental design for a refrigerator, as shown and described.

RAYMOND LOEWY.



PATENT PROTECTION

for Product Appearance

CARL C. BATZ
Patent Attorney

Design piracy can be prevented and the advantages of an artistic design secured solely to the owner by taking advantage of the law pertaining to design patents

DURING the fiscal year 1936 there were 6,127 applications to the United States Patent Office for patents on designs, and more design patents were issued this year than in any previous year in the history of the Office. Almost twice as many design patents are being issued now as there were two years ago. This clearly indicates an awakening interest in design protection on the part of the American manufacturers, it is also another indication of the fact that manufacturers are becoming aware of design possibilities and are wisely spending money to develop new designs for their products.

This added interest may be principally because of the changing attitude on the part of the customers who are coming to consider more and more the appearance of the articles they are purchasing. An article which merely gives good service is no longer satisfactory, because the customer now demands that it be good looking as well. When two articles of the same class and equally serviceable are presented to the present day customer, and one of the articles has a striking and unique appearance while the other appears only as an ordinary product, it is safe to say that the customer will be attracted to the better appearing article even though it be slightly higher in price.

However, there are always unscrupulous competitors who are waiting to copy a new design just as soon as it comes on the market, and so profit at the expense of others who have worked out the design. This is known as design piracy, and if it were not for this, there would doubtless be much greater incentive toward the development of individual designs for products.

Such design piracy can be prevented and the advantages of the artistic design secured solely to the owner by merely taking advantage of the law pertaining to such patents. Probably most managers of companies are not aware that such protection costs very little.

The Law

The authority upon which design patents are issued comes from the Federal Revised Statutes, Sec. 4929, stating in part,

> "Any person who has invented any new, original, and ornamental design for an article of manufacture . . . may . . . obtain a patent therefor."

This federal law is based on Article 1, Sec. 8 of the United States Constitution which reads in part,

> "The Congress shall have the power . . . to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their writings and discoveries."

It may be noted that this constitutional provision is the basis of all United States patent laws.

What Is a Patentable Design?

Only the appearance of an article, the impression that it gives to the eye, is protected by a design patent. The certain combinations of line and form which give to the article its individual beauty and cause it to make an impression upon the observer are what go to make up the subject matter of the design patent. In speaking of what may be patented as a design, the United States Supreme Court has said,

> "Design, in the view of the patent law, is that characteristic of a physical substance which, by means of lines, images, configurations, and the like, taken as a whole, makes an impression, through the eye, upon the mind of the observer. The essence of the design resides not in the elements of the design individually, nor in the method of arrangement, but in the tout ensemble—in that indefinable whole that awakens some sensation in the observer's mind. Impressions thus imparted may be complex or simple, in one a mingled impression of gracefulness and strength, in another the impression of strength alone. But whatever the impression, there is attached in the mind of the observer to the object observed a sense of uniqueness and character."
>
> —*Pelouze vs. American Cutlery, 102 Fed. 916.*

It is clear that a design patent may be obtained on almost any conceivable manufactured article. In looking through the lists of recently issued patents, articles of a varied nature are seen. For example, there are radios, pencils, dresses, belt-buckles, shoes, toys, lamps, pieces of furniture, containers of all kinds, bottles, textile fabrics, saxophones, table wear, and so on, ad infinitum.

The first requirement of the patentable design is that it be new and original. It must present to the eye of the observer a different effect from any other design which is known at the time. It must involve originality and must be the product of genius, at least in some degree. The application of old designs to new purposes, however suitable they may be to the new purpose, is not patentable.

If a design differs over another existing design only by having some of its lines extended or by having some particular idea in the design enlarged or changed only slightly, it is not patentable. There must be a difference which renders the new design distinctive in appearance and which produces a different effect on the ordinary observer. There is no invention in copying the things found in nature. For example, the design of anything in the form of an apple or a banana would not be the subject of a design patent. In one case it was attempted to patent the design of a toy balloon in the form of a watermelon, but no such patent could be issued because the design was not new and original but had long been common in nature itself.

There are cases where parts of the new design are found in different places among old designs, and this frequently raises a question as to the patentability of the new design. If the effect of the new design is no more than the sum of the effects of the old designs, there is no basis for patent protection. But if the new design along with the additive effects mentioned, produces also a distinctive appearance because of their combination, then the new design does include subject matter for patent protection. In determining whether such a design is patentable it must be viewed as a whole, and if the effect when so observed is different from all other designs known, then the design possesses that novelty required by law.

Another requirement for patentability as a design is that the article have at least some aesthetic appeal. It must have something like style, possess some sort of ornamental form or shape, or at least must have some attraction other than the mechanical usefulness of the article. It is, of course, realized that what may be beautiful to one person may not seem beautiful to another, and the law does not require a beauty according to the standard of the fine arts, or any certain standard, but at least some sort of rudimentary aesthetic appeal is required. It is not sufficient that the article be merely unobtrusive.

The design patent protects only that which is seen and deals with lines, forms and shapes. The movement or operation of an article, or how the article may be used to perform any special result is not dealt within a design patent, and such a patent is no protection therefor. If the peculiar appearance of the article is obtained by purely mechanical or utilitarian features, it is not patentable as a design. However, the fact that an article is meant to operate and is a useful article, does not preclude the issuance of a design patent if the article also possesses a unique or attractive appearance as well, but design patent protection covers only the particular appearance of the article. The features of the article which make it operative or useful are protected by the usual mechanical patent.

How a Design Patent Is Produced

A design patent is procured in much the same way as any other patent. The application consists of the drawing, specification, oath, and so forth, and should be prepared by a competent patent attorney. Patents may be had for terms of either 3½, 7, or 14 years. The 3½ year term patent requires a $10 government fee, the 7 year term patent a $15 fee, and the 14 year term patent a $30 fee. The applicant has the privilege upon request of changing the term of the patent to be issued, to a greater or lesser term with a consequent adjustment in the government fee. The Patent Office has now arranged a special Design Division which can handle design applications very quickly and can usually give an action on an application in less than thirty days after it is received in the office. The promptness with which the design applications are dealt with is also a factor which makes this type of protection more valuable to the designer. Another factor which makes the design patent particularly attractive is the fact that it is much less expensive and can be obtained for only a fraction of what a regular mechanical patent would cost.

The Value of a Design Patent

The value of a design patent may well be estimated by asking oneself the question, "How much is it worth to me to be able to use this new design and keep every one else from using it during the term of the patent?"

From a competitive sales standpoint, it would seem that the advantages of design patents have been largely overlooked in the past. Suppose, for example, that a manufacturer of kitchen ranges secures patent protection on a range design which is particularly appealing to women and which becomes the mode or style of the day. Only the patent owner or his license would be able to manufacture ranges of this design and it is easy to guess whose products would be in demand. Most ranges could be depended upon to work well, but only this particular maker's product could embody the style so effective in influencing purchasers.

The artistic design is no longer just a mere novelty to be toyed with and then discarded according to whim or fancy. Now, designs are regarded more as property having a substantial money value that the law can and will protect.

What Users Want in
MOTORIZED MACHINERY

Comments and criticisms of plant engineers with respect to motors and controls and the way they are incorporated in the design of production machinery

"DO THE electric drive on your machines meet all your requirements? Do the motors ever overheat or stall? Are they conveniently inspected, cleaned, lubricated? Can they be replaced quickly in the event of trouble? How about the controls? Do they continue to perform their proper function after long use, without too frequent adjustment? Are they accessibly located for easy wiring and ready inspection? In short, what points, if any, in the design of your motors and controls, or in the way they're incorporated in your machines, have caused you inconveniences or contributed in any manner to difficulties in keeping them on the job and keeping production up to par?"

These are but a few of the questions put to the chief electrical engineers of a number of representative plants using modern individually driven machines purchased with motors and controls attached to or incorporated in them. To the credit of motor and control manufacturers and designers applying electric drives, reports show that failures are rare, troubles infrequent, inconveniences and difficulties only occasional. This was as expected since, after all, motors and controls have been undergoing a process of improvement and refinement for the last half-century and have thereby reached a high stage of development. However, much of the information gathered indicates certain preferences of plant engineers and explains reasons for users' likes and dislikes.

Concerning the inherent electrical design of motors and controls, the users had no criticism to offer. Motors, as manufactured today, are available in such a wide variety of electrical characteristics and ratings that in only a few instances is there any difficulty in obtaining one that will efficiently handle the load cycle imposed upon it. Similarly, controls are obtainable in numerous forms to meet the electrical characteristics of the motors for which they are intended.

In general the basic mechanical design of motors also met with the approval of plant engineers. As to controls, however, several of the men interviewed believe that it would be a great improvement if control manufacturers standardized their products in somewhat the same manner as motor frames and mounting dimensions have been standardized. Thus, they would like to have, for example, such parts as coils, contacts, and thermal elements interchangeable, as well as having interchangeable mounting dimensions for the various units in a control system. Another point mentioned with respect to controls was that in some designs too much emphasis is being placed on compactness at the expense of other factors such as convenience of wiring, sturdiness, and accessibility for repairs. Some of the pressed steel cases used on controls, for example, were cited as being too small for convenient wiring and too light to withstand the bumps and knocks to which they are sometimes exposed.

FOR VALUABLE ASSISTANCE in compiling this article, the editors take the opportunity to thank Mr. Leonard Bogardus, Packard Motor Car Company; Mr. John Byrnes, Worthington Pump and Machinery Corporation; Mr. R. C. Howell, Wright Aeronautical Corporation; Mr. A. C. Sachse, Dodge Brothers Corporation; Mr. F. I. Wheeler, Tiffany and Company; and the many other plant engineers whose expression of opinion is reflected in this article.

Numerous preferences with regard to service requirements were expressed. These include such factors as protection against dirt, dust, and moisture, provision for lubrication, location of the various units, inclusion of desirable accessories, and other points related to the consideration of motors and controls not as individual units but as interconnected parts of the entire electric drive for the machine.

For the machine-shop applications, totally inclosed motors are greatly preferred to open-type motors because of the prevalence of metallic dust. With open motors, small particles of iron or steel are drawn into the motor and attracted magnetically to the coils. There, experiments show, they are acted upon by the magnetic fields within the motor in such a way that they stand on end and go into a vibrating spin, thereby soon drilling through the insulation and causing the motor to "go to ground." With totally inclosed motors, of course, this condition is avoided since the external air does not reach the motor windings.

For the same reason, semi-dust-tight housings are considered advantageous for all control devices used in machine shops.

Motor insulation is also adversely affected by grinding compound and by oil; consequently a number of users prefer totally inclosed motors for all wet-grinding machines and for use in locations where oil is present in either mist or vapor form. The latter point is illustrated by the experience of one plant electrician with a milling machine which had an open-type motor placed in the machine base and just below the motor was an oil well. When heavy work was being performed, the oil returned to the well at a relatively high temperature and the vapor from it was drawn into the motor windings, impregnating them with oil. Although the motor was cleaned once a week and the windings wiped off as thoroughly as possible, it was necessary to rewind the motor about once every eight or ten months. A totally inclosed motor, or design of the machine to exclude the oil system from the motor compartment, would have obviated this unfortunate situation.

Where ball-bearing motors are used, grease lubrication is considered satisfactory as long as the motor is kept in fairly frequent operation. However, a number of the users pointed out that grease becomes so hard after standing in a motor idle for say six months that it is impossible to force it out by pumping fresh grease in to the bearing. As

a result, it is necessary to disassemble the bearings, clean them, and then repack them with fresh grease before the machine can be started. For this reason, these users prefer oil lubrication for their ball-bearing motors, a constant-level bottle-type oiler being employed to maintain the oil-level at the proper point. This type of lubrication consumes only about an ounce of oil a year and functions automatically.

To prevent the entrance of metallic dust, dirt, and grit, the bearings should be equipped with a good seal. For slow-speed oil-lubricated bearings, a modified "grease seal" bearing is being used by one manufacturer. In this bearing the outer edge of the steel seal ring is notched in order to allow the oil to flow into the felt.

One plant engineer suggests that mist lubrication would be ideal since it would then be possible to tell by the sound when a bearing was badly worn.

In almost every interview, the subject of lubrication led into a discussion of inbuilt motors. Although the chief electricians recognize the advantages of this design, they were practically unanimous in preferring to have the motor mounted on top of the machine where it could be easily inspected and oiled. The reason is that with the inbuilt design the front bearing of the motor is usually located so far inside the machine housing that it is difficult to reach. Ordinarily Tony, who does the job of periodically lubricating the motors, will take the time to wriggle one arm into a position enabling him to get at the front bearing. But sometimes, perhaps on a Monday morning after a hard week end, he skips it. Result: there's a hot bearing on Friday and a repair job for the electrician to worry about getting done on a rush basis so that the week's production can be finished on schedule.

Accessibility Is Important

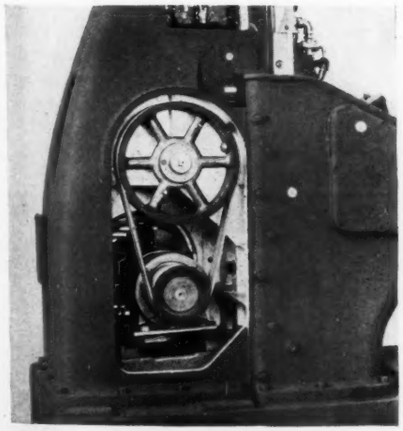
At one plant where a number of machines were of a design which might tempt Tony to shirk his duty, copper tubing was used to carry grease from a fitting on the outside of the machine to the front bearing of the motor. This solution has worked out well except for grease-lubricated ball-bearing motors on which the bearings are not provided with a pressure-relief arrangement. When lubricating such machines, Tony just can't get out of the habit of "giving 'em the works" as he would in greasing the shackles on his flivver. The result is over-lubrication of the motor bearing, so that it runs hot and eventually causes trouble. The solution, it appears, is to provide not only an external grease fitting but also an external pressure-relief outlet.

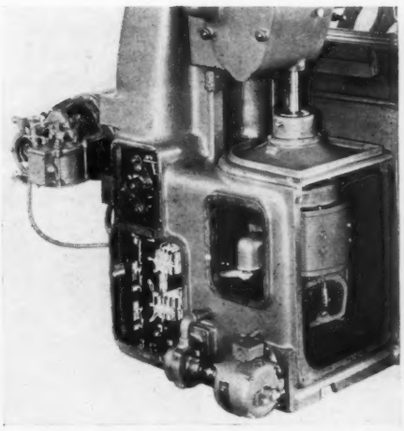
When motors and controls are inbuilt, plant engineers prefer machines with spacious pockets for these units, accessible through large openings with easily removable and replaceable covers. With respect to covers, those which are hinged are considered more desirable than those held in place with snap-on clamps. The latter are easy enough to remove but are often difficult to replace; hence Tony is tempted to leave them off after his periodic cleaning of the equipment, especially if they're located where they are not likely to be noticed.

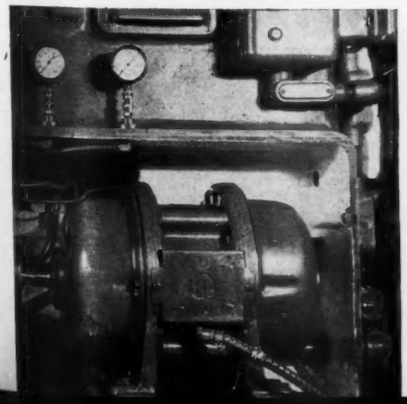
Another factor to be considered is that of making adequate provision for wiring and rewiring between all inbuilt units of the electrical system. On one machine, the motor starter was located so close to the floor that all wiring had to be brought in from the top. This necessitated running some of the wires very close to the starting resistors which, frequently being hot, soon caused the insulation to fail. In another instance, it was found that the terminal box was located on the wrong side of the motor. When the end-shields were removed and the motor reversed, it was discovered that the wires originally provided would not reach and they had to "tear down half the machine" in order to rewire it.

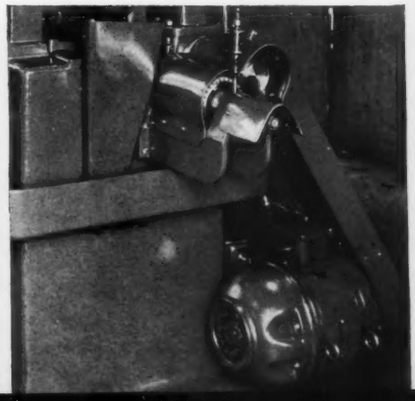
For these reasons, the plant engineers like to have all wiring located, if not out in the open where it can readily be inspected, at least in such a position as to permit its being easily replaced. Further, it is recommended that solid conduit be used for all wiring except where flexible conduit must necessarily be provided. The seams in flexible conduit, it was explained, allow cutting solution and oil to enter and deteriorate the insulation, so that grounds some-

In general, plant engineers demand accessible motors, plenty of room for wiring, adequate provisions for lubrication and easy inspection









times develop as often as in from six months to a year. Seamless flexible metal tubing, in place of the usual flexible conduit, was suggested by one user as a possible remedy.

As to the type of wiring from the electrical point of view, some preference was expressed in favor of single-wire control circuits over the double-wire type. With the single-wire system a short-circuit to ground will not cause the control to operate and start the machine.

For alternating-current operation, the use of 110-volt circuits for the control system is preferred since this voltage, reduced from the higher-voltage motor circuit, minimizes the possibility of flashovers and provides greater safety to the operator. For this reason, several users insist that all machines driven by motors operating on 440 volts or higher be equipped with a step-down transformer to provide for 110-volt operation of the controls. In addition, they like to have the transformer provide sufficient capacity, over and above that needed for the control system, so that supplementary lighting circuits and signal lights may also be connected to it.

One electrician in charge of a large plant suggests that every machine equipped with a magnetic chuck should have an individual rectifier or motor-generator set to supply direct current to the chuck. Such an arrangement confines the "inductive kick" created by the opening of the chuck circuit to that circuit and prevents the surge from causing flashovers in other circuits.

Types of Switches Preferred

Disconnect switches and air circuit breakers are other electric devices with which the majority of users prefer to have their machines equipped. At one plant, plain disconnect switches are put on all machines up to 10 hp. and air circuit breakers on all machines of 10 hp. and higher. The latter is considered a better arrangement than to have other protective devices, which might be incorporated in the control system, operate when a short circuit or sudden overload occurs.

From the standpoint of operator convenience, lever switches or palm buttons are preferred when operation is frequent. For infrequent operation there seems to be little preference between palm buttons and finger-type pushbuttons. However, the recessed button of the finger type was criticized by one plant engineer because the operator may catch his fingernail on the stationary rim projecting beyond the button. This user favors the type in which the button extends slightly beyond the button guard.

Although not a frequent condition, the location of pushbuttons is sometimes changed, after the machine has been installed, so that the operator can manipulate the controls without taking steps. In one machine the control was taken off and installed on a rack. A secondary set of pushbuttons incorporated in a portable pendant switch would have made the makeshift arrangement unnecessary. Such a switch can be carried by the workman while operating the machine from the floor or it can be hung from some convenient support adjacent to the point where the operator may be required to stand. When not required, the pendant switch is removed from operation by throwing a lever switch on the main panel and the latter is then used to control the machine.

Over Power or Under Power?

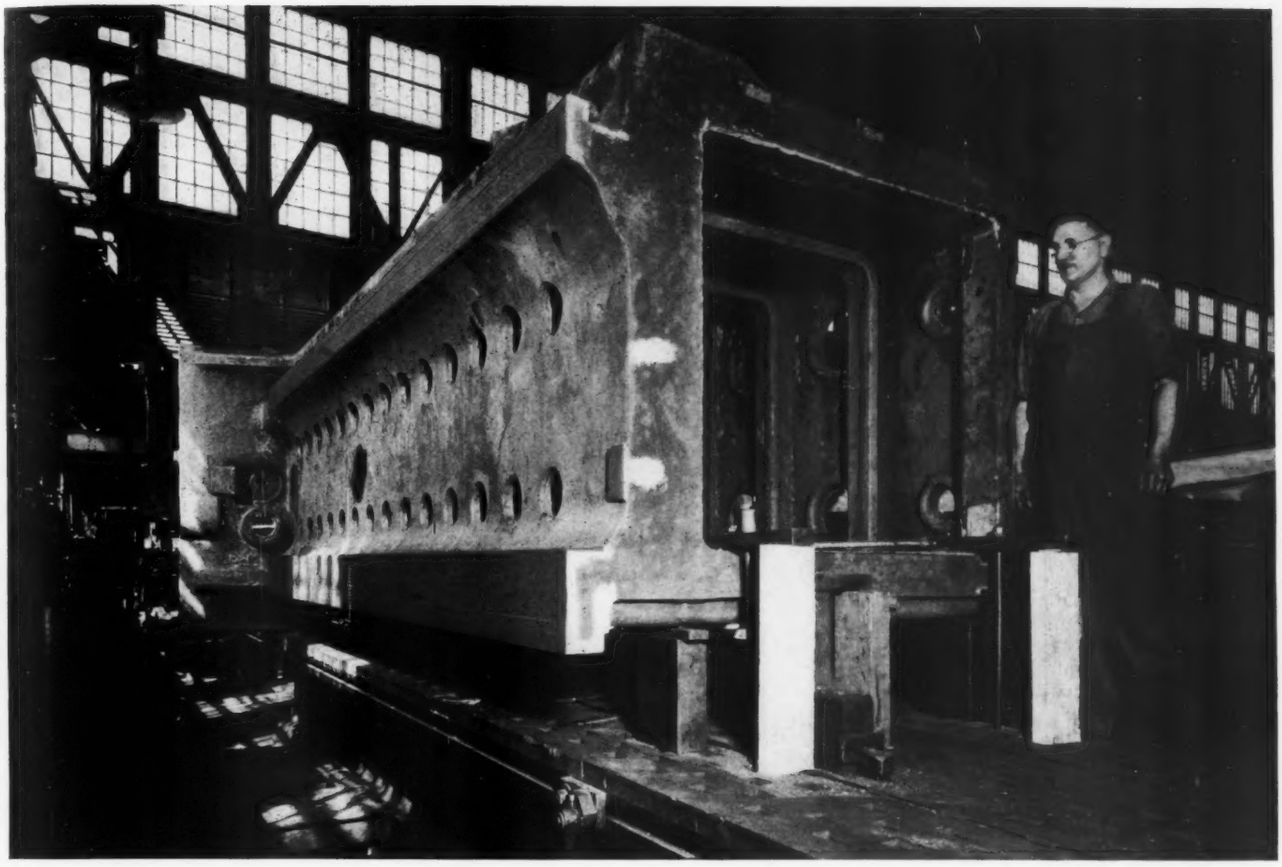
In connection with the application of pushbuttons, two somewhat unusual conditions were reported to have caused considerable difficulty. In one, the pushbuttons were on a stud grinder. Oil and emery dust on the operators' hands got into the pushbuttons and put them out of operation as often as once a week. A lever switch would have prevented this difficulty. In the other application, the pushbuttons were used to start and stop a tool grinder. Instead of pushing the buttons with their fingers, the operators found it more convenient to work them with the hot tool which they were grinding. As a result the molded plastic buttons had to be replaced at all too frequent intervals. Here also a lever switch offered an easy way of correcting the difficulty.

With reference to the less common types of motors, it was observed that the shell type of motor is not as popular as the standard unit-frame type because when the former are used on machines it is usually necessary to carry a stock of special spare parts for them. Flange-mounted motors are liked because of the ease with which they can be aligned, but some users have found them inconvenient since various motor manufacturers have used various mounting dimensions and the motors were therefore not interchangeable. It is understood, however, that recently at least several motor manufacturers have adopted the same mounting dimensions.

On one point there was a considerable divergence of opinion. Users of a fairly large connected load of motors were of the opinion that in too many cases their machines were over-powered, that is equipped with motors more powerful than is required to drive the machine. When a motor is operated at a lower load than that for which it is designed, its efficiency and power-factor are low, contributing to a higher bill for power. A large number of motors operating in this way adds an appreciable amount to the cost of production as compared with the same number of motors, of smaller size, operating at full load or nearly so. However, with only a few machines in a plant, this factor does not have as much weight and the user generally prefers to spend a little more money for power in return for the "margin of safety" provided by the larger motor. An example is a lathe that was motored for cutting aluminum. When an attempt was made to cut cast iron, it was found that the motor was not powerful enough. In a small plant this machine would be frowned upon; in a large plant it would be commended.

Such are the conditions which the user expects the designer of electrified machines and electrical equipment to foresee and provide for. Different applications, different locations, different users, all require different emphasis on the various design factors in the one machine. The most judicious compromise produces the most acceptable results.

It takes a long reach sometimes, as in this instance, to lubricate the front bearing of motors built into machine castings



Upright for floor boring machine, weight 45,000 lb., with sections varying from 1⅛ to 6 in., the ways were cast without chills

QUALITY IRON CASTINGS

in Modern Mechanical Designs

P. E. McKINNEY, *Metallurgical Engineer, Bethlehem Steel Company*

Recent developments in the use of alloys and the effective control of the carbon and silicon content has increased the uses and applications of iron castings in many industries

MODERN machinery designers, in their constant quest for materials of improved physical properties have been greatly benefited by the advances made in foundry practice during the last decade. Following the example of the steel maker the foundryman has endeavored to improve the physical properties of his castings by the use of alloys, and with equal success. Tensile strengths up to 60,000 lb. per sq. in. and hardnesses up to and above 700 Brinell are now available in commercial castings. Greater uniformity of structure and improved machinability, increased resistance to abrasion and wear, to high temperatures, corrosion, growth and creep, are some of the advantages gained by the use of alloys.

Among the interesting developments during this period of metallurgical advance is the increasing use of alloy pig iron in the production of high quality cast iron. This method gives a perfect distribution of the alloys in the castings, and it also permits an effective control of carbon and silicon, whereby appreciable savings in more expensive alloys are sometimes made possible. That these advantages are appreciated by designers is well illustrated by the fact that during 1936 no less than 500,000 tons of castings were made from mixes employing alloy pig irons, an increase of more than 100 per cent over the preceding year. Based upon figures for the first three months of 1937, a similar increase may be anticipated for the current year.

The applications include practically every type of commercial castings, with the automotive industry leading by a comfortable margin. Light and heavy machinery castings, tools, heat and wear resistant castings are other outlets.

In the development of the new types of cast iron, the primary object was to

Desilverizing pots used in lead refining, the largest pot is a 17,275 lb. casting

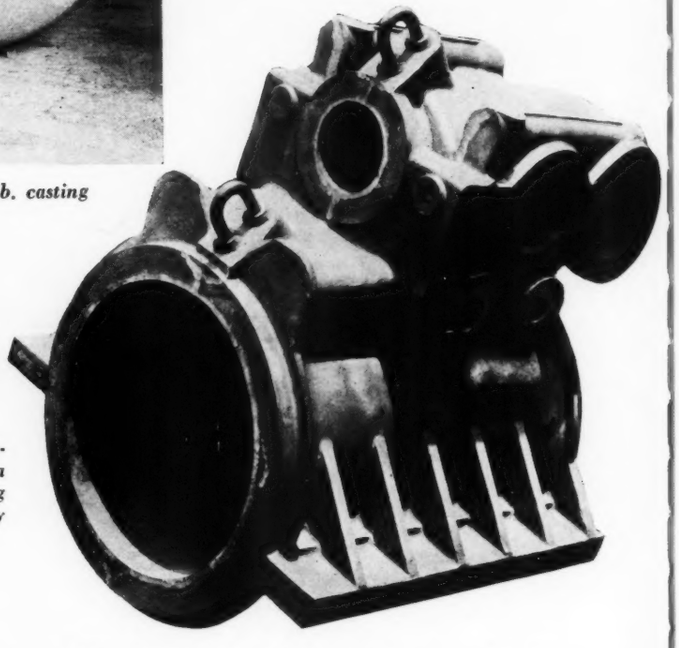
raise the strength and hardness, without sacrificing the favorable characteristics such as fluidity and machinability. The alloys most commonly employed are nickel and chromium, which to a certain extent are opposite in their action. Nickel dissolves in the iron in all proportions and acts as a graphitizer, making the metal soft and machinable. Chromium, on the other hand, is a carbide-forming element; in small additions it increases the hardness without materially affecting the ductility; it promotes a fine grain structure, increases the density, and improves the physical properties.

However, the designer who wishes to take full advantage of these two alloys must not overlook the importance of a correct silicon-carbon control. Silicon, like nickel, acts as a graphitizer. By maintaining the silicon content on the high side, with a comparatively low carbon, a nickel chromium ratio of 1 to 2 has been found satisfactory in the production of a great variety of castings.

Such a carbon-silicon control is particularly easy to attain by using an alloy iron of a type similar to that produced by one of the larger steel companies in this country. This iron is obtained by smelting an ore of low, but constant content of nickel and chromium. Such an iron can be made with a high silicon content, up to 12 per cent, or with a content of 3 per cent or less, as the case may require. The carbon content varies accordingly, from 2 to 4 per cent.

The perfect distribution of the alloys which results when castings are made with such a pig iron insures a high uniformity of the grain structure, without hard or soft spots. As the metal losses in the cupola are negligible the castings will contain the exact percentages of alloys desired. Furthermore, as a properly prepared charge, with the alloys perfectly distributed, passes through the melting zone, certain chemical actions are retarded, others are facilitated which could not be affected without this intimate and prolonged contact.

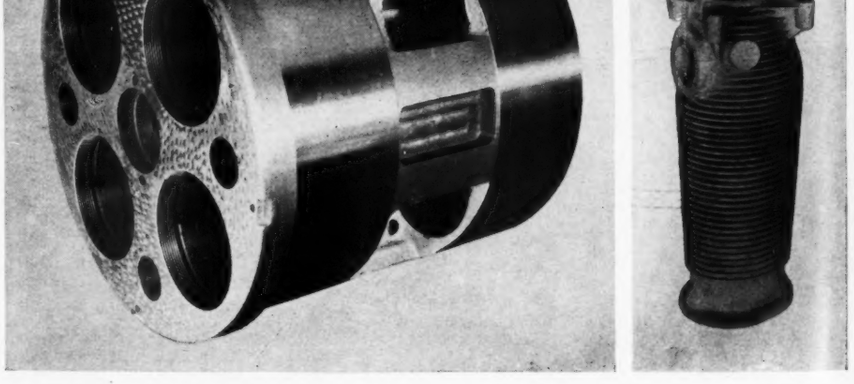
By the proper proportioning of alloy iron in the cupola mix the desirable combination of strength, structure, soundness and wear-resistance can be obtained with a remarkably small percentage of the alloys in the finished castings. The reason for this is that the alloy is present as a natural ingredient of the components of the charge which react during the process of melting and blending in the cupola and, therefore, exert their maximum efficiency in improving the structure. As pointed out in the preceding paragraphs, the proper balance of silicon, carbon and the alloying agents, nickel and chromium, is highly important.



An intricate cylinder casting for a compressor having light and heavy sections

Many automotive designers are now specifying alloy pig iron mixes for cyl-

Spindle carrier, 20 in. diam., with light and heavy sections—note the high polish and the smooth threads cut in the heavy section. (Right) An airplane cylinder made of quality cast iron



Twenty ton roll casting for ore crusher

inder blocks, in passenger cars, trucks and tractors, to insure a sound homogeneous structure with the proper resistance to heat, wear, and abrasion. Such blocks have a hardness of 196 to 217 Brinell and machine easily; hard bores which do not soften in service are obtained, and there is practically no annealing action of the core on the cylinder bore. Transmission cases, flywheel housings, carburetor castings, and intake manifolds are other applications in the automotive field.

Most enlightened buyers of castings demand from the foundry a product that will fulfill a certain purpose, and permit the foundryman to use any material that will meet these requirements. In most cases the buyer does not attempt to hold the foundry down to specified analyses. The figures given in the subsequent examples are to be taken as indications of compositions only, and must not be interpreted too literally. The physicals represent what may be expected in good foundry practice. To visualize in detail the effect of these additions is not an easy task, and the accumulated experience of designer, metallurgist, and production man is essential in order that full advantage may be taken of the high quality irons.

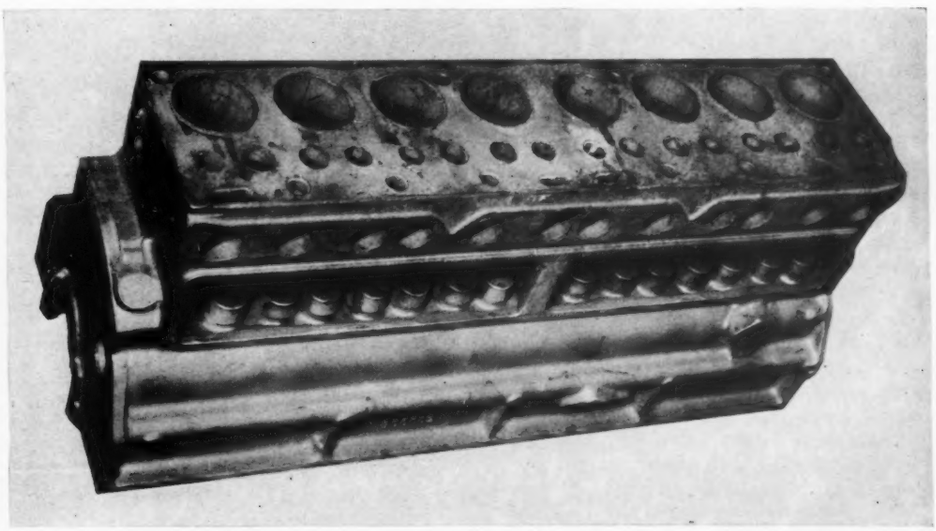
A typical composition for gears, worm wheels, and other readily machined parts, with variations in sections from $\frac{3}{8}$ in. to 3 in., is 0.22 chromium, 0.15 nickel, 2.35 silicon, 3.10 carbon, and phosphorus below 0.20. A tensile strength of 40,000—50,000 lb. per sq.in., and a hardness of 217—235 Brinell are obtained in these castings. Sheaves and similar heavily stressed parts are made according to the following specifications: 0.45 chromium, 0.25 nickel, 2.0 silicon, 3.0 carbon, 0.75 manganese, 0.14 phosphorus. This composition will give a tensile strength of 50,000-55,000 lb. per sq. in., and a hardness of about 240 Brinell.

In heavy castings such as steam engine cylinders, lathe beds, boring mills, swivel tables, flywheels, with variations in section from 1 to 6 in., the silicon content is dropped to 1.9-2.0, and carbon to 2.9, while nickel and chromium are held at 0.22 and 0.45 respectively. Such castings show a tensile strength of about 50,000 lb. per sq.in., and a hardness of 200-260 Brinell. The fine grain structure imparted by alloy pig iron is especially marked in heavy machine tool castings; the commonly used practice of chilling the ways to obtain a close grain structure is never resorted to, not even with the greatest variations in sections. All T-slots have the same close grained surface as the ways, with no crumbling of the edges.

Designers rarely think of cast iron as a suitable medium where torsional stresses are encountered, yet alloy cast irons are now used for machine tools, where gear and shafts are cast integral. Typical examples of this are sheaves for high-speed elevators, cast integral with the gear, with tensile strength better than 45,000 lb. per sq.in., and rotors for high pressure pumps cast integral with the shafting. Alloy cast iron is even being seriously considered for propeller shafts for high speed vessels of several thousand tons displacement; its property to deaden vibrations is of particular value in this use.

Many designers are now showing a decided interest in bearings made of alloy cast irons. A common analysis is 0.45 chromium and 0.34 nickel, and a tensile strength of 50,000 lb. per sq.in. or better should be specified. The latter is important, not because any such stresses occur in the bearing, but be-

Automobile cylinder block requiring uniform hardness in all sections. To the left is shown a steam cylinder made of quality cast iron



cause the fulfillment of this requirement insures the proper homogeniety in the metal. A careful carbon control, with a high graphitic carbon, and a low combined carbon, is also necessary to insure good machining and lubricating properties. Such bearings can be used with any metal, and must always be lubricated. A recent installation, for an 8 in. shaft, was made for 400 tons pressure.

Castings for diesel engine liners must be exceptionally sound, with dense structure throughout and minimum porosity; they must machine well and take a high polish. High test cast irons made from alloy pig iron have proved satisfactory in this service; the diesel liners on the Burlington Zephyr are made of this material. A commonly used composition is as follows: 0.45-0.50 chromium, 0.30 nickel, 2-2.10 silicon, 0.55-0.65 manganese, 0.25 phosphorus; tensile strength, 43,000-45,000 lb. per sq.in., transverse strength 5,000-5,300 lb. per sq. in., deflection 0.19-0.22 inch, hardness 225-250 Brinell, and 180,000-200,000 lb. per sq. in. in compression.

Wear resistant castings fall in two main categories. very hard or white castings, and castings which are hard but which still have retained their machinability. Because of their uniform grain structure castings made with alloy pig iron can be machined up to 300 Brinell.

White castings, for extreme abrasion, call for a low silicon content, 0.5-0.9, with 2.75-3.0 carbon, 0.2-0.5 nickel, and 0.4-0.1 chromium. With such a low silicon, these castings must be made with a high phosphorus content, 0.2-0.4, to insure sufficient fluidity. Castings of this type, with hardness from 430 to 710 Brinell are used for plates, liners, rolls, jaws, and balls in crushing and grinding machinery; for sand blast nozzles, pump liners, and many other parts subject to excessive wear. An interesting application is for the polishing plates used in cutting diamonds. These plates have a hardness above 700 Brinell and are 1½ in. thick. They are used until they have worn down to ½ in. in thickness.

Frequently it is necessary to provide for heat resistance in addition to abrasion resistance. Applications of this type are grate bars sintering machines, wire dies, hammer dies, piercing plugs for tube mills, rolling mill guides, bending boxes for pipe mills. To attain this objective the silicon content is raised to 1.25-1.50 in heavy sections, and 1.5-2.25 in light sections, with carbon at 3.0-3.1, and 2.9-3.0 respectively; nickel is held at 0.25, and chromium at 0.6, and sulphur and phosphorus should be as low as possible. Lately designers have also been specifying heat dissipating properties which by raising the carbon content to 3.1-3.35 may be obtained.

Where heat resistance alone is required as in melting pots and annealing pots, the following analysis has proved satisfactory: 0.30 nickel, 0.60 chromium, 2.50 silicon, 3.0 carbon, 0.10 max. phosphorus. An annealing pot of this composition used with intermittent heating and cooling, for temperatures up to 1,700 deg. F., was found to outlast ordinary cast iron pots five times.

Molds used in the casting of glass have always been difficult to manufacture, and many designers are now specifying alloy cast iron for this purpose. These molds are subject to severe strains by intermittent exposure to high temperatures. They must have a close grained machinable surface, of uniform hardness to permit the necessary carving and etching of the fancy designs used on much of the molded glass ware. To attain this, and to insure the necessary heat resistant and heat dissipating properties a close carbon control is essential.

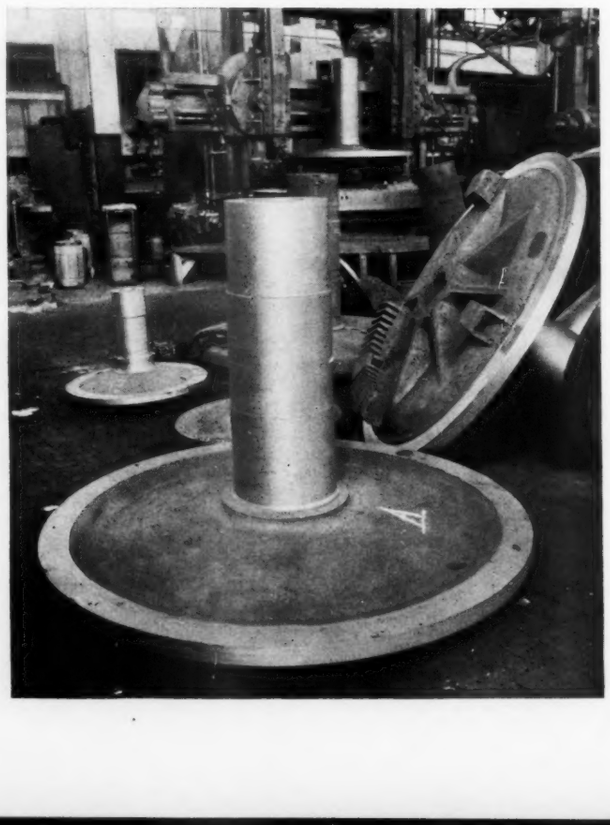
In designing machinery for refrigeration and air conditioning, for domestic as well as for industrial use, it is imperative to obtain easily machined castings with close grain structure and freedom from internal shrinkage. The new modern refrigerants have far greater penetrating power than air, water and ammonia. Many manufacturers are now using alloy iron for compressors, and reservoir castings, for sections between 3/16 and 3 in., and have been able to dispense with the sal ammoniac treatment formerly resorted to for filling the pores of these castings.

Another illustration of the density and sound grain structure of such castings is furnished by their use in the production of hydraulic cylinders of 12 in. section, capable of withstanding a hydrostatic pressure of 4,000 lb. per sq.in. Castings of much thinner sections, high pressure valves, with 1¼ in. wall thickness, for service up to 1,400 lb. per sq. in., exhibited no porosity or leaks when subjected to 4,000 lb. per sq.in. pressure, which was the capacity of the available testing equipment. This pressure was sufficient to shear off some of the steel bolts used in the assembly.

Some of the largest castings made with alloy iron are the drawing dies used in the manufacture of automobile turret tops, radiator shells, barrels, kegs, and other metal containers.

Like alloy steels, quality cast irons can also be improved by heat-treatment, although the possibilities in this direction are far more limited. Large pieces of irregular sections are sometimes annealed to remove casting strains. Increased surface hardness and greater transverse strength can be obtained by heating to 1,550 deg. F., followed by a quench in oil. Die-casting pots handling molten metal under pressure heat treated in this manner showed an increase in surface hardness from 196 to 477 Brinell. An interesting feature was the small growth that resulted, only a few hundredths of an inch. Annealing after the heat treatment may again reduce the hardness should it be desired. Heat-treatment is frequently used for machine tools, line shafting, tool housings, and similar parts.

Drier head for paper machine cast integral with shaft



Various types of corrosion-resistant castings are also made with alloy iron mixes. The complexity of the corrosion problem, and its many controversial features make it impossible to give an unqualified recommendation to any one composition without the precautionary measure of a thorough test in each specific case.

The examples given by no means exhaust the possibilities, but they suffice to demonstrate to the machine designer that high test cast iron is really a new material, a material which can hardly be put in the same class as ordinary gray foundry iron.

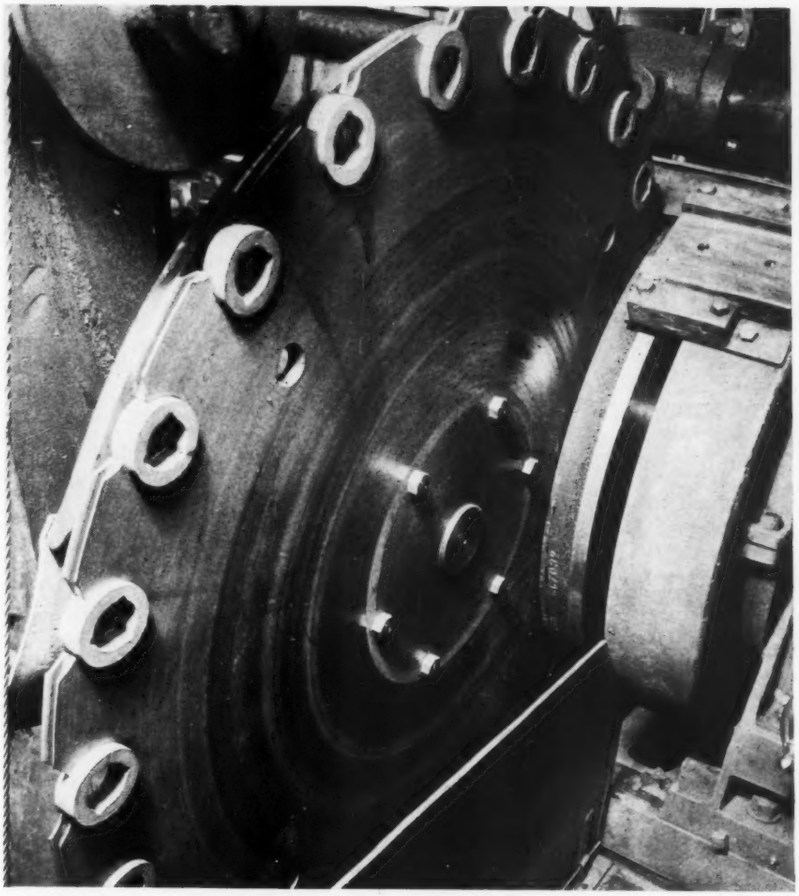


Fig. 1—Grinding to finished dimensions, after heat-treatment, is the only fabrication operation feasible with unit castings made of the newer magnet materials

PERMANENT MAGNETS—II

Their Manufacture—Materials and Shapes

J. DELMONTE

ONCE the designer has determined the magnetic requirements of a certain application, as discussed in Part 1 of this article, it then becomes necessary for him to consider the various magnet materials which might be used and to select the one most suitable. This selection is influenced not only by the magnetic characteristics of the magnet material but also by its physical charactistics, including its formability and machinability both before and after heat-treating, and by other factors affecting its processing.

Details of processing are of importance to the designer inasmuch as it may prove less costly for his concern to purchase the magnet material before it is heat-treated and magnetized. In fact, it is very frequently the better practice not to magnetize the material until after assembly, because then it will not pick up extraneous particles during handling or make positioning difficult. Moreover, when this procedure is followed, the flux density will usually be greater than it would be if the materials were first magnetized and then assembled. The reason for considering whether heat-treatment should precede or follow purchase is that the older permanent materials may be formed and machined to some extent before heat-treating but afterward become so hard

Photos by McGraw-Hill Studios, of subjects furnished by the Cinaudagraph Corporation

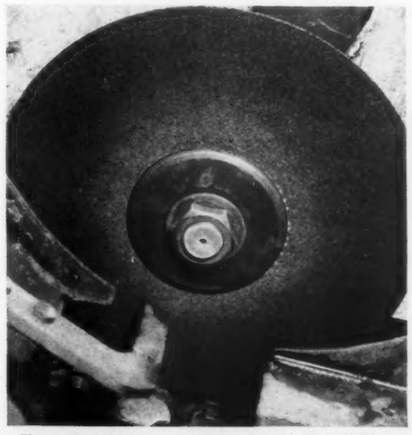


Fig. 2—With newer materials, a design of magnet that can be cut-off from bar castings may often be most economical

Table 1—Properties of Permanent Magnet Steels

Data obtained from manufacturers' bulletins, current literature (Bell Sys. Jl. Vol. 14, p. 8, and Metal Treatment, p. 43, 1935) and patents

Alloy Steels	*Residual Magnetism (Gausses)*	*Coercive Force (Oersteds)*	*Energy Product BsHs(max.)*	*Heat Treatment*
1% Carbon-Steel	9,000	50	200,000	Quench at 800 deg. C. in water
3% Chromium Steel (Carbon 0.9)	9,000	65	250,000	Quench at 830 deg. C. in oil
6% Tungsten Steel (Carbon 0.75)	11,000	70	300,000	Quench at 845 deg. C. in water
36% Cobalt Steel (3–4% W, 1–3% Cr. 0.75% C)	11,000	240–300	1,100,000 to 1,500,000	Quench at 950 deg. C. in oil
Aluminum–Nickel Alloys				
25% Nickel	6,000	600	1,300,000	Quench from 1200 deg. C. in oil
10–17% Aluminum	8,000	510	1,750,000	
Modified by Va, Co	9,800	440	1,800,000	
Cr, W, ("Alnico")	7,200	430	1,300,000	
New Honda Steel: 15–36% Cobalt 10–25% Nickel 8–25% Titanium	7,000	800	2,400,000	.....

and brittle that no fabrication other than grinding and finishing is feasible because of the great hardness.

The heat-treating process is critical, and a few degrees difference may determine whether or not a batch of magnet steel will be satisfactory. The magnet steel is heated to the recalescence point of the alloy, to put all the carbon into solution. Above this point, the steel loses its magnetic properties, but on the lower side of this critical temperature, suitable quenching will produce the requisite hardness and retain magnetic properties.

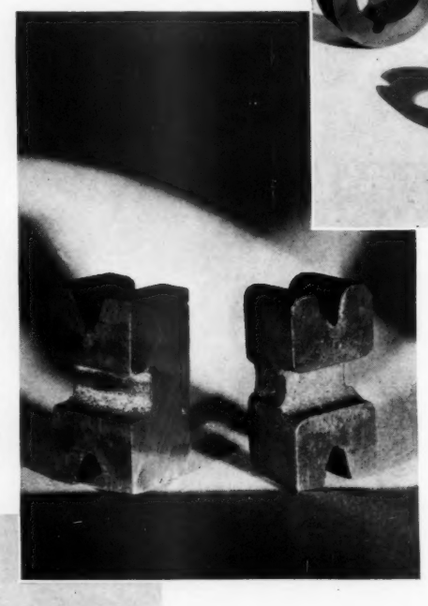
Table I summarizes the magnetic characteristics of the more important magnet materials and includes a column showing the heat-treatments required by them. The first four are the so-called older materials. They are available in cast forms and rolled bars, and, as mentioned above, are formable and machinable before heat-treatment. The last two are the newer nickel-aluminum materials. They are available only as castings, since even before heat-treatment they are so hard and brittle that fabrication is limited to cutting by an abrasive disk and grinding operations, such as Fig. 1 and Fig. 2 illustrate.

Where it is found desirable to use the older materials, the designer must decide whether the permanent magnet should be cast or produced from bar stock. Recent improvements in hydraulic presses make it easier to bend the material into the desired shape than was the case a few years ago; consequently simple magnetic circuits that can be manufactured from rolled bars may offer certain advantages.

Sometimes, after forming and machining, further processing of these materials may be necessary before hardening and magnetizing. For example, one manufacturer of compass needles of cobalt steel found that a considerable quantity of the carbon content was lost in hot-swaging the bar stock at 1,000-1,100 deg. C. It was necessary to carburize the finished specimens in a carbon compound for 12 hours at 850 deg. C., in order to restore the carbon content.

Where high values of coercive force or energy product are required and where, therefore, use of the new nickel-aluminum alloys is indicated, the designer is confined to cast shapes. Though complicated castings have been produced commercially, economy of design usually dictates that the shapes be kept as simple as possible and, because the material chills quickly during casting, sections appreciably smaller than ¼ in. should not be used without first consulting the magnet-material manufacturers. When feasible, a design of magnet which can be cut-off from cast bars such as are shown in Fig. 3, may often be

Fig. 5—Grooves for clamping bolts simplify casting and are preferred to holes, as indicated by design of these loud-speaker magnets



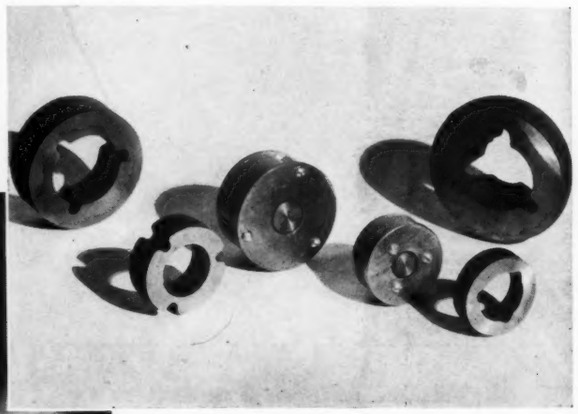


Fig. 4—Magnets cut from a bar-shaped casting, such as one shown at left, can frequently be designed to approximate shapes achieved by unit castings, such as one at right

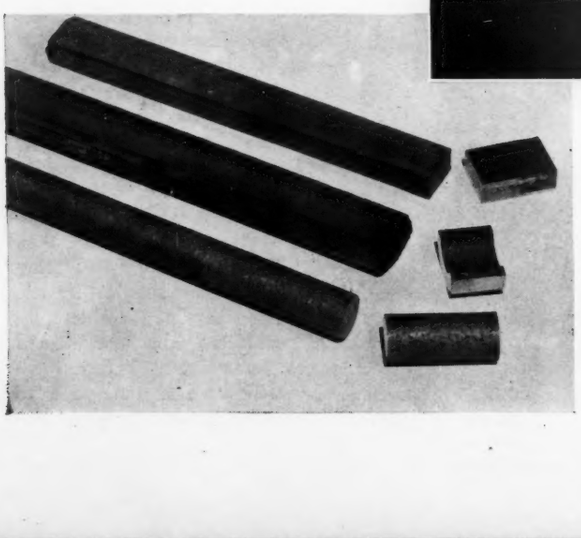


Fig. 3—Several of the bar shapes in which the new nickel-aluminum magnet materials may be cast, permitting economical production of shorter magnets by means of cut-off operation

most economical. As illustrated in Fig. 4, cut-off parts can frequently be designed to approximate very closely the shape of unit castings.

In the design of castings, all necessary holes should be of generous dimensions, so that they can be cored easily. Where possible grooves instead of holes should be used to provide for clamping bolts, as indicated by Fig. 5. Parts, such as magneto rotors, requiring a relatively small accurately located hole for the shaft may be cast with a soft metal insert like that used in the small casting shown in Fig. 6. The large casting in the same illustration shows how one designer solved the problem of making a fairly complicated part relatively simple to produce.

Sometimes the simplest castings are not the most economical. Thus in a heavy casting, simplicity may result in increased leakage losses. Consider, for example, the large loud-speaker magnet shown in Fig. 7. It weighed approximately 17 lb., and was given a "streamlined" section at a small increase in pattern cost but with an appreciable reduction in leakage loss. The streamlining decreased the weight of the magnet and hence its overall cost.

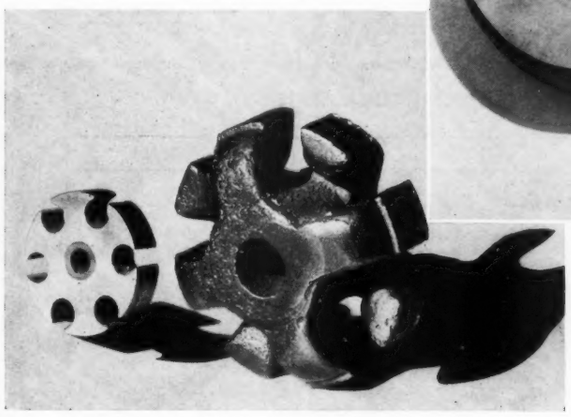


Fig. 6—Small casting features soft metal insert into which accurately located hole for shaft can be drilled. Large casting illustrates simple design for fairly complicated part

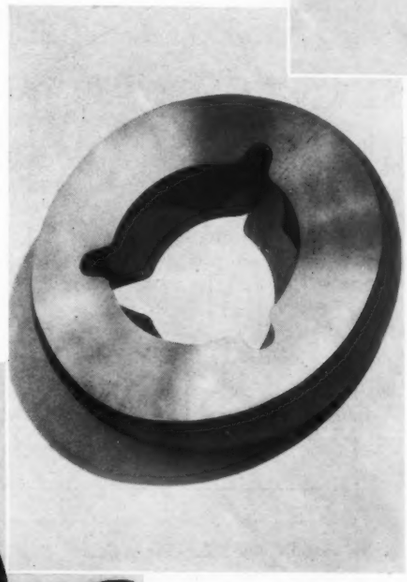


Fig. 7—Because of "streamlined" section, leakage loss in this large, 17-lb. loudspeaker magnet is minimized and overall cost reduced

Occasionally such factors as complexity of casting, leakage losses and difficulty of machining, can be circumvented by using a fabricated part made up partly of die-castings. An outstanding example is the Wico Electric Company's magneto rotor which is fabricated by die-casting aluminum around a bronze insert and two magnets cut-off from cast bars of Nipermag, the permanent-magnet material made by the Cinaudagraph Corporation. In this design two laminated pole pieces are first spot welded to the two permanent magnets. Then, as shown in Fig. 8, the bronze bushing is inserted in the center and the aluminum is die-cast around the whole subassembly. This provides material to which the rotor-shaft flange can be fastened and imparts a unified appearance to the entire assembly.

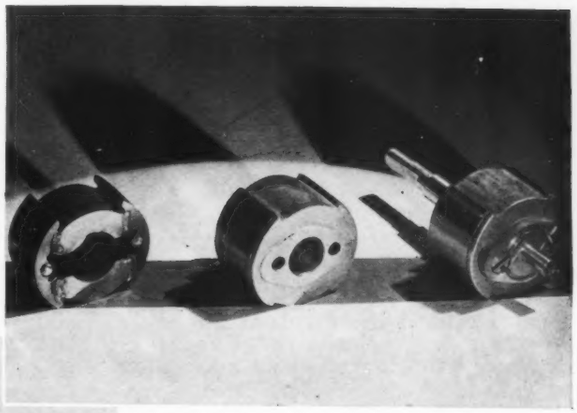


Fig. 8—In this fabricated rotor for the Wico magneto, spot-welding and aluminum die - casting contribute to strength, ease of production, and unified appearance. Progressive stages shown from left to right

When permanent magnets have been heat-treated and ground to finished dimensions, they are ready for assembly and, after that, for magnetization. In magnetizing them to saturation, materials with high coercive forces require high magnetizing forces, the following being typical to attain full remanence:

Aluminum-nickel steel: 2,000 gilberts per cm. (4,040 amp. turns per in.)

36 per cent cobalt steel: 1,500 gilberts per cm. (3,030 amp. turns per in.)

Tungsten steels: 400-500 gilberts per cm. (810-1,010 amp. turns per in.)

The magnet materials are magnetized by placing them, with poles suitably located, in the field of a coil or combination of two coils through which a heavy electric current can be passed. When materials are magnetized before assembly, an iron "keeper" is sometimes placed across opposite poles of the magnet. The purpose of the keeper is to provide a complete magnetic path during magnetization and its use, where indicated, results in greater residual magnetism. The keeper is not removed until the magnets are actually assembled and the magnetic path completed.

After magnetization, the permanent magnets lose a certain percentage of their residual magnetism when subjected to demagnetizing influences such as heat, shock, and adverse magnetic fields. The new nickel-aluminum alloys, however, are distinguished by their inherent resistance to such influences; the loss of residual magnetism in them, during this "aging" period, is but a small percentage of the total remanence and most of it occurs within a day or so after magnetization. It is this greater assurance of permanency that has paved the way for their use in applications for which designers previously were reluctant to adopt a material having characteristics that changed over relatively long periods of time.

On the other hand, when the older permanent-magnet materials are being used in applications where constancy of magnetic energy is highly important, they can often be treated or "aged" to prevent loss of magnetism over long periods of time. Thus, for applications in which heat is prevalent, the materials may be heated at 100 deg. C. for several hours, until no further demagnetization occurs. Likewise, the materials may be artificially jarred, or subjected to artificial demagnetizing fields, until such influences produce no further change in magnetism. At this new lower but more permanent residual magnetism the desired constancy of magnetic energy is realized.

Examples of both common and unusual designs that illustrate the versatility of permanent-magnet applications will be given in Part III of this article, which will appear in the June issue of Product Engineering.

Part III

STANDARDS FOR SPRING DESIGN

W. M. GRIFFITH
Product Engineer, Atlas Imperial Diesel Engine Company

Parts I and II in March and April *P.E.* covered materials specifications, working stresses and calculations. This concluding installment presents drawings, tolerances and inspection standards

IN ORDER to standardize the procedure in the design of springs, the calculation for each spring should be made on a form such as illustrated in Fig. 13. All information required by the form should be provided so that a complete record may be kept for future reference. Data concerning the actual dimensions and characteristics of the spring, as received from the manufacturer, should be obtained from the inspection department, and recorded as indicated on the form.

All spring drawings shall be made on 8½ x 11 sheets and need not necessarily be to scale. The wire size shall be specified in decimals of an inch for round material, excluding all gage numbers, and in fractions of an inch for square or rectangular material. For rectangular material the thickness should be shown opposite a spring coil in addition to specifying the size at the bottom of the sheet, in order to indicate how the material is wound. The finish, if any, and the material to be used must be indicated on the drawing. If possible, the tolerances as given in Table IV should be used in dimensioning the drawings. If closer tolerances are required, the dimensions should properly provide for them, although as great a tolerance as possible should always be specified. Load tolerances shall be indicated as plus or minus in order that the mean value will correspond with the specific rate.

A sample of a compression spring drawing is shown in Fig. 14. Every compression spring drawing bears the following notations: "Springs must be straight and compressible to 'minimum working length' without coils touching or taking a permanent set." Compression spring dimensions should include only pitch, minimum working length, free length, and maximum outside and

TABLE IV - PERMISSIBLE MANUFACTURING TOLERANCES

OUTSIDE DIAMETER	VARIATION +OR-	LENGTH	VARIATION +OR-	PITCH	VARIATION +OR-	LOAD
Smaller than 1/8	0.003	Less than 1	1/32	4-Coils or less	1/4 Coil	PLUS OR MINUS TEN PER CENT
		1 to 2	1/16			
1/8 to 1/4	0.005	2 to 3	3/32	4 to 8 Coils	1/2 Coil	
1/4 to 1/2	0.008	3 to 5	1/8			
		5 to 8	5/32	8 to 15 Coils	3/4 Coil	
1/2 to 1	0.015	8 to 12	1/4			
1 to 2	1/32	12 to 18	3/8	15 to 25 Coils	1 Coil	
2 to 3	1/16	18 to 24	1/2			
		24 to 30	3/4	Over 25 Coils	2 Coils	
Over 3	3/32	Over 30	1			

Fig. 13—Facsimile of form for use in making spring calculations and recording all the data including actual dimensions and characteristics of the spring as received from the manufacturer

ENGINEERING STANDARDS

SPRING DESIGN

Drg. No. S-2494 Class 1 Rate 60 Max. O.D. 2 9/32 Min. I.D. 1¾

Pitch 0.550 F.L. 6¼ M.W.L. 3.325 Material M5-12 Size 0.2437 DIA.

Length of Arm _____ Length of Rod _____ Max. Def. _____

CALCULATIONS

$N = \frac{3.325 - 0.55}{0.268} = 10.35$ $\quad (D-d) = \frac{\text{Max. O.D.} + \text{Min. I.D.}}{2} = 2.015$

$F_N = FL - MWL = 2.925$ $\quad P = \frac{G \times d^4 \times F_N}{8 \times (D-d)^3 \times N} = \frac{11{,}500{,}000 \times 0.003527 \times 2.925}{8 \times 8.2 \times 10.35} = 175$

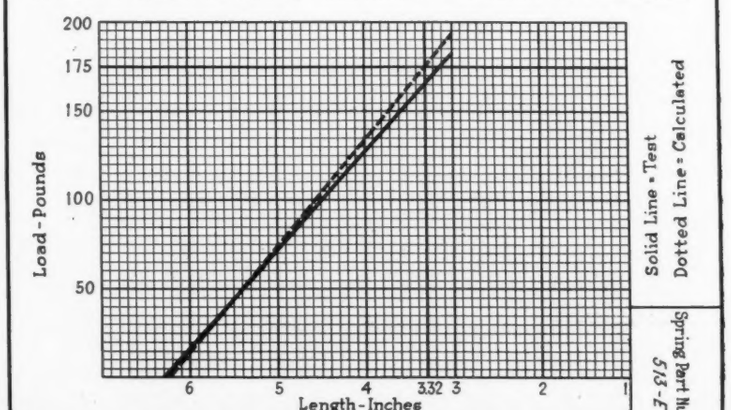
$\text{Rate} = \frac{P}{F_N} = \frac{175}{2.925} = 60$ $\quad S = \frac{2.015 \times 175}{0.3927 \times 0.01447} \times 1.18 = 73{,}200$

$\text{Pitch} = \frac{6.25 - 0.55}{10.35} = 0.550$ $\quad$ Solid Length = $(10.35 + 2.25) \times 0.2437 = 3.07$

ACTUAL VALUES

F.L. 6 9/32 N 10.5 Load 58 Def. 1" Solid Length 3⅛ O.D. 2 9/32 d 0.24

Set 1/64 Average of 10 Springs. Total Turn 13 Manufactured By W.D. GIBSON



Spring Part Number 513-F

Original By	Date	Checked By	Date	Tested By	Date
GRF.	2-9-36	AND.	2-25-36	GAW	3-25-36

APPROVED BY	DATE ISSUED	SUPERSEDING	SUPERSEDED BY	REVISION DATES
	April 17, 1936			

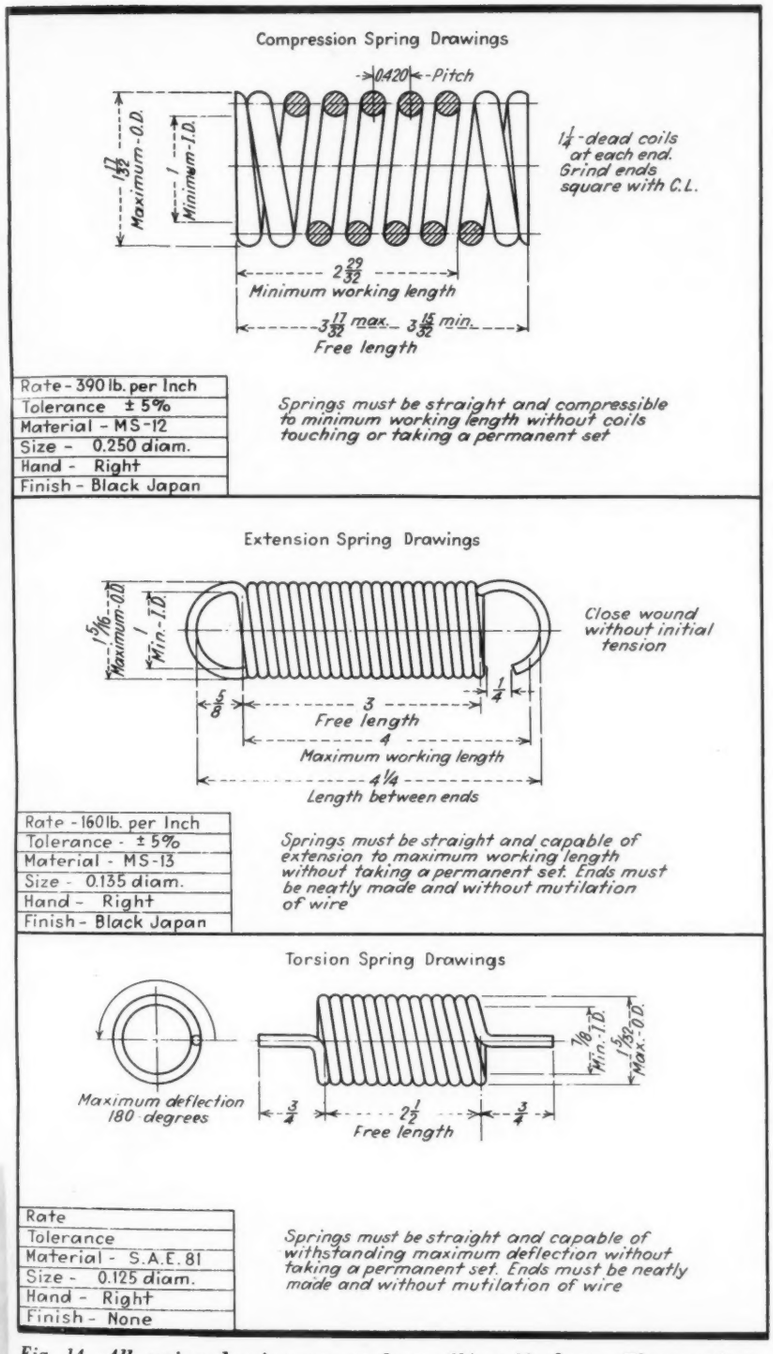

Compression Spring Drawings
.0420 - Pitch
Maximum - O.D.
Minimum - I.D.
1¼ - dead coils at each end. Grind ends square with C.L.
2 29/32
Minimum working length
3 17/32 max. 3 15/32 min.
Free length
Rate - 390 lb. per Inch
Tolerance ± 5%
Material - MS-12
Size - 0.250 diam.
Hand - Right
Finish - Black Japan
Springs must be straight and compressible to minimum working length without coils touching or taking a permanent set
Extension Spring Drawings
Maximum - O.D.
Min. - I.D.
Close wound without initial tension
5/8
3
1/4
Free length
4
Maximum working length
4 1/4
Length between ends
Rate - 160 lb. per Inch
Tolerance - ± 5%
Material - MS-13
Size - 0.135 diam.
Hand - Right
Finish - Black Japan
Springs must be straight and capable of extension to maximum working length without taking a permanent set. Ends must be neatly made and without mutilation of wire
Torsion Spring Drawings
Maximum deflection 180 degrees
3/4
2 1/2
3/4
Free length
Min. - I.D.
Max. - O.D.
Rate
Tolerance
Material - S.A.E. 81
Size - 0.125 diam.
Hand - Right
Finish - None
Springs must be straight and capable of withstanding maximum deflection without taking a permanent set. Ends must be neatly made and without mutilation of wire

Fig. 14—All spring drawings are made on 8½ x 11 sheets. They need not be to scale, but must bear the notations as given in the above examples

minimum inside diameters. All data indicated in the table on the specimen drawing must be furnished.

Extension spring drawings should be made as shown in Fig. 14. They shall bear the following notation: "Springs must be straight and capable of extension to 'maximum extended length' without taking a permanent set. Ends must be neatly made and without mutilation of wire." The drawing must state whether the spring is close wound, with or without initial tension, and if open wound, the pitch must be specified. Extension spring should include only the free length from center of first active coil to center of last active coil, maximum working length, length between ends and the maximum outside and minimum inside diameters. In addition, complete details of the ends should be given showing one or both end views, if necessary. All data indicated in the table on the specimen drawing must be furnished.

It will be noted that the steel materials are specified on the drawings with the number of the materials specifications. The specifications sheets are in the hands of the manufacturers who furnish the springs. Thus every material specification is tied to the spring drawing and makes it necessary for the manufacturer to furnish material in accordance with the specifications.

The calculation and check sheet shown in Fig. 13 has been used for some time by the Atlas Imperial Diesel Engine Company with excellent results. When considering an existing spring for a new design all of the data required are at once available. Much time is saved and the possibility of error in recalculating the spring is eliminated.

Inspection rejection and identification of springs are made in accordance with the following specifications.

Inspection, Rejection and Identification of Springs

All springs received at the plants shall be carefully inspected, tested and marked, where required, for identification.

Inspection shall cover all specification requirements noted on the spring drawing and on the material specification sheets. Particular care should be exercised in inspecting the material to make certain all defects noted on the material specification sheets are absent. In case of doubt one or two springs from the shipment in question should be etched in a 30 per cent solution of boiling hydrochloric acid for a sufficient length of time to reduce the diameter 0.002 in. to 0.003 in. After etching all material or manufacturing defects are readily discernable.

A sufficient number of springs from each shipment shall be tested to determine if the spring rate is within the limits specified on the drawing. The amount of set, if any, when compressed to the minimum working length must also be determined.

All springs failing to meet the requirements referred to above shall be rejected. If more than 10 per cent of the springs on any one order are rejected the entire shipment shall be rejected.

Springs constructed of music wire, monel metal, phosphor bronze or brass shall not be marked in any way for identification. Springs made of the steels indicated shall have one or two coils at one end painted a color corresponding to that indicated as follows: Swedish steel, blue; Carbon steel, orange; Chrome Vanadium steel, red. The paint used shall be quick drying, oil proof, heat resisting lacquer.

One phase of the problem of spring design should be emphasized. When designing a mechanism which incorporates a spring, it is of utmost importance that the dimensions of the spring be determined early in the design.

MECHANICAL AUTOMATIC

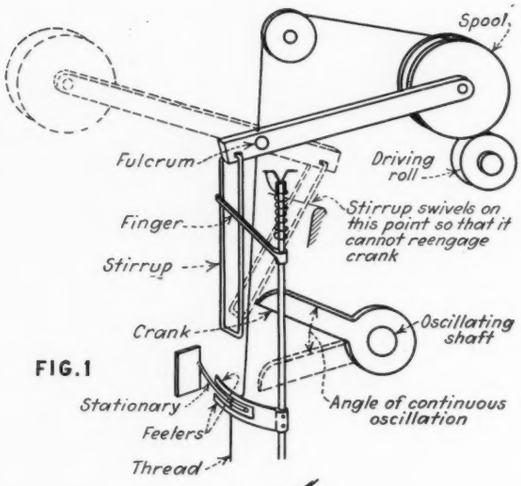


FIG. 1

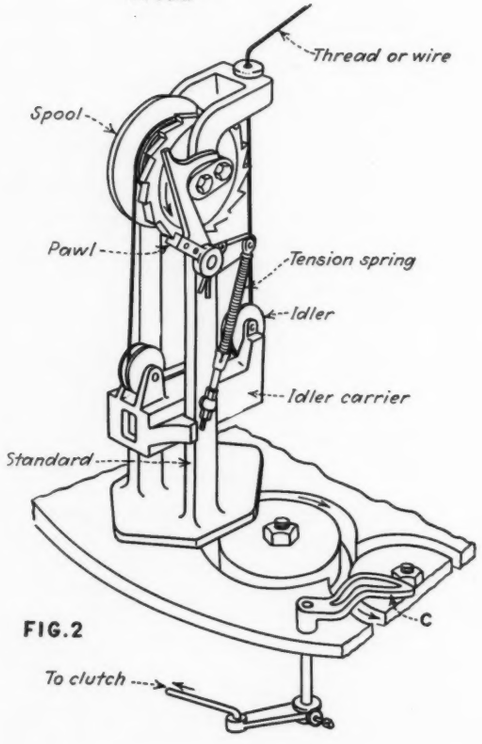


FIG. 2

FIG. 1—A mechanism used on the Barber-Colman spooler. When thread breaks the feelers are released and the spiral spring causes the spindle with finger to rotate. Latter throws the stirrup into the path of the oscillating crank, which on its downward stroke throws the spool into the position shown dotted, the stirrup then being thrown out of the path of the oscillating crank.

FIG. 2—Mechanism used with variations on tubular braiding machines. When braiding, tension on the wire or thread lifts the idler carrier which thereby releases the pawl from the ratchet on spool flange and allows the spool to turn and unwind. When machine stops the tension on wire is decreased allowing the idler carrier to fall so that the pawl can engage the ratchet. If wire breaks while the machine is running the unsupported idler carrier falls to the base of the standard and when the standard arrives at the station in the raceway adjacent to the cam *C*, the lug *L* on idler carrier strikes the cam *C*, rotating it far enough to disengage a clutch on the driving shaft, thereby stopping the machine.

FIG. 3—When thread breaks the stop drops and intercepts reciprocating bar. On the next counter-clockwise oscillation of the eccentric arm the bar *B* is raised. A feature of this design is that it permits the arm *B* to move up or down independently for a limited distance.

FIG. 4—Schematic diagram of mechanism to cause bobbin changer to operate. If contact arm does not slip on bobbin the lever *A* will rotate to the position shown. But if contact with bobbin center slips, as it will do if the bobbin is empty.

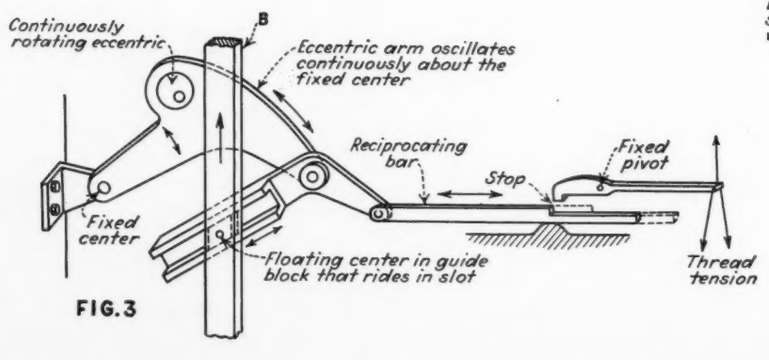


FIG. 3

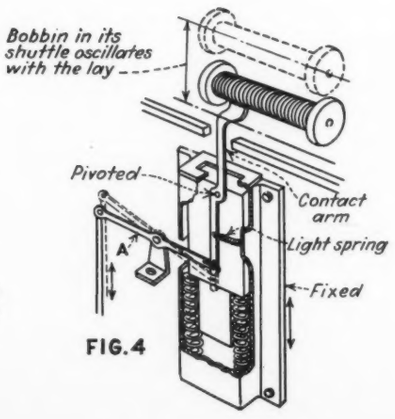


FIG. 4

Designs shown here diagrammatically were taken from textile machines, braiding machines and packaging machines. Possible modifications of them to suit other applications will be apparent

STOP MECHANISMS

lever *A* will not rotate to position indicated by dashed line, thereby causing bobbin changer to come into action.

FIG. 5—Simple type of stop mechanism for limiting the stroke of a reciprocating machine member. Arrows indicate the direction of movements.

FIG. 6—When the predetermined weight of material has been poured on the pan, the movement of the scale beam pushes the latch out of engagement, allowing the paddle wheel to rotate and thus dump the load. The scale beam drops, thereby returning the latch to the holding position and stopping the wheel when the next vane hits the latch.

FIG. 7—In this textile machine any movement that will rotate the stop lever counter-clockwise will bring it in the path of the continuously reciprocating shaft. This will cause the catch lever to be pushed counter-clockwise and the hardened steel stop on the clutch control shaft will be freed. A spiral spring then impels the clutch control shaft to rotate clockwise, which movement throws out the clutch and applies the brake. Initial movement of the stop lever may be caused by the breaking of a thread, a moving dog, or any other means.

FIG. 8—Arrangement used on some package loading machines to stop machine if a package should pass loading station without receiving an insert. Pawl finger *F* has a rocking motion obtained from crankshaft, timed so that it enters the unsealed packages and is stopped against the contents. If the box is not filled the finger enters a considerable distance and the pawl end at bottom engages and holds a ratchet wheel on driving clutch which disengages the machine driving shaft.

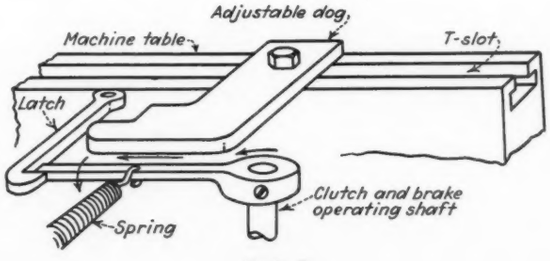


FIG. 5

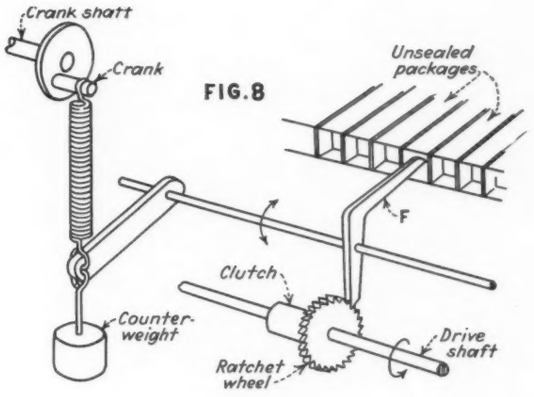


FIG. 8

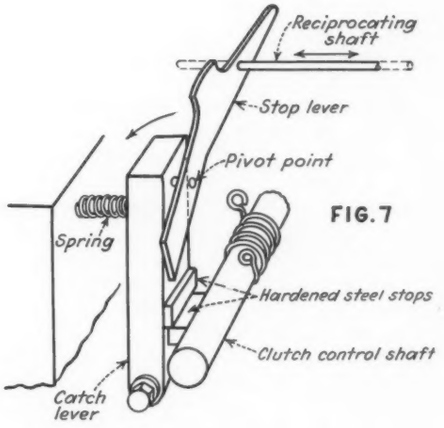


FIG. 7

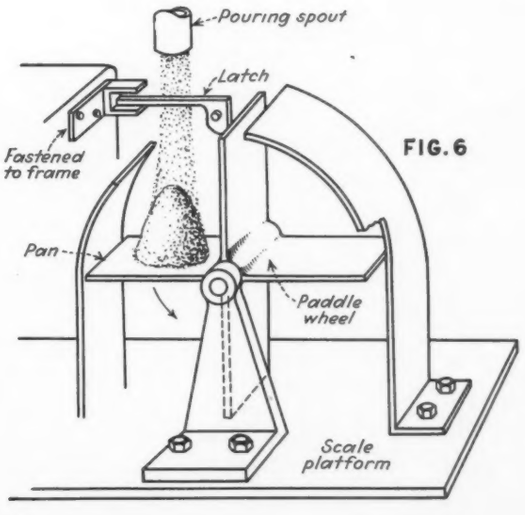


FIG. 6

Question and Comment

Opportunities in Drafting

E. S. CROCKER
Frank Wiggins Trade School

Frequently engineers are approached for advice by young men who would like to know what the prospects are for positions in drafting. For this reason, some of the facts on this subject, which were gathered together for the use of students at the Frank Wiggins Free Trade School in Los Angeles, Calif., may be of interest.

Many draftsmen do not have a college education; nevertheless they earn a good living wage and are engaged in a very interesting type of work. As they work they encounter many problems which necessarily increase their fund of knowledge and, if they utilize their time in evening studies, they may progress to higher positions which are well paid and which do not necessarily require a college degree. Drafting, in fact, often leads to engineering work and, for those who have the ability, there are many opportunities in this field.

The accompanying tables summarize the more interesting facts about drafting and engineering work in this country. As the figures show the drafting field offers earning potentialities well above the average. However, with a 53 per cent increase in the number of draftsmen between 1920 and 1930 and with 137,000 draftsmen, engineers and inventors in the country at the present time, there is naturally considerable competition for the better-paying positions in this field.

A fact which should be called to the attention of the young man interested in becoming a draftsman is the need for men who have been trained better than just average. There are relatively few positions open for apprentices in drafting work, because when men of this type are being hired, there is usually designing work to be done as rapidly as possible and the better-trained men are the ones who get the jobs. It is necessary, therefore, for the young man to secure his training either through some school, or at least, through home study under the guidance of someone who is capable of instructing the beginner until he has gained sufficient skill and knowledge to enter the field and do some of its easier work with the speed required by the engineering departments today.

For those who may be called upon to assist in the training of young draftsmen, there is considerable literature available. A pamphlet, sponsored by the Society for the Promotion of Engineering Education and the American Society of Mechanical Engineers, covers arrangement of views, line work, section lining, methods of cutting sections, dimensioning, and tolerances, and calls attention to many possible standardizations. There are also a few samples of lettering as used today in most drafting rooms. This booklet should be in the hands of every instructor of drafting, because of the general adoption of the practices of standardization that are found in it.

Many of the drafting associations are attempting to standardize drafting room practices and there is a general tendency towards standardization in all engineering departments. An article by U. A. Whitaker in the April, 1936 issue of *Product Engineering* gives good material in a chart with information about organizing the different problems of an engineering department, and shows the relationship between research and the development of designs. Another article in the July, 1936 issue of the same magazine, written by J. K. Olsen, presents a thorough discussion of drafting room methods and practices, and shows copies of many cards and record-keeping forms which may be introduced into a drafting room to cover those operations which it is possible to standardize. The dimensioning of drawings, methods of handling revisions, and the wording on rubber stamps for obsoleting the blueprint or cancelling the authorization of a design are shown with explanations.

A quick picture of the opportunities open to young men in the field of drafting and allied work is provided by the facts tabulated here

Monthly Salaries

NON-GRADUATE ENGINEERS

Age Group	Average (1934)
28–32	$150.
33–37	200.
Over 37	310.

GRADUATE ENGINEERS

Experience	Average (1934)
2 yr.	$140.
12 yr.	190.
Over 12 yr.	350.

Races in Engineering Work

	Percentage
DESIGNERS	
Native white	64.79
Foreign-born white	30.98
Negro	2.82
Others	1.41
DRAFTSMEN	
Native white	92.35
Foreign-born white	6.72
Negro	.62
Others	.31
INVENTORS	
Native white	73.25
Foreign-born white	26.25
Negro and others	.50

Age Distribution

	Percentage of Total Number		
Age	Draftsmen	Designers	Inventors
Under 19	7.4	6.5	0.
19-23	35.3	20.0	1.
24-29	30.3	24.5	2.
30-39	15.6	21.0	5.
40-49	7.0	14.5	46.
50-59	3.2	10.5	30.
60-69	1.2	3.	16.

Sleeve Bearing Materials Wanted

To the Editor:

We would like to obtain information relative to sleeve bearing materials for use with shafts of Monel, 18-8 stainless steel, bronze and other corrosion-resistant alloys. These bearing materials

must resist temperatures as high as 400 deg.F. and chemical attack from 30 per cent sulphuric acid solutions while strong caustic solutions should not cause electrolysis. Shafts will run at a speed of 400 r.p.m., the shaft sizes being from 1 in. to 3 in. diameter. We are interested in solid metallic bearings, impregnated bearings and plastic bearings. Any data or suggestions will be sincerely appreciated.—E.S.B.

[*Editors Note*: The article on page 67 of the February 1937 number under the caption of "What Type of Bearing Is Most Suitable?" will probably be of some interest to E.S.B. In this installation wherein graphited bronze bearings were originally used, the temperatures reach 500 deg.F. at times because of a steam line running through the bearings to the drum of a carbonator type of digester. The imposed bearing load was 42,600 lb., and rotating speed was 1 r.p.m. Undoubtedly there are many other instances illustrating unusual bearing applications.]

Chart for Proportioning Shafting

SALVATORE F. CAVALLI
Dover, N. J.

In order to provide a convenient means of properly proportioning shafting that is subjected to torsion only, the accompanying nomographic chart,

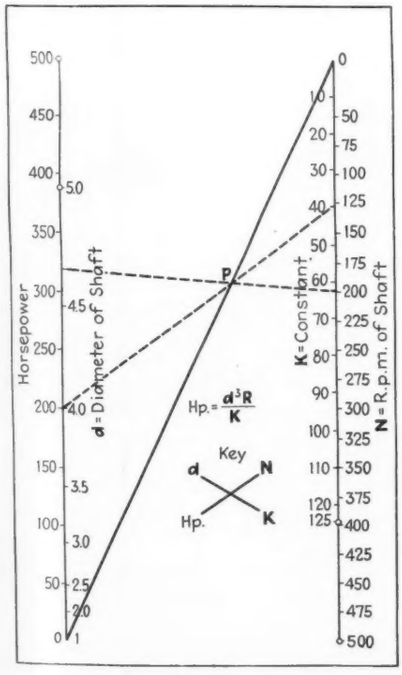


Fig. 1—Chart for determining diameters of shafts subjected to twisting only

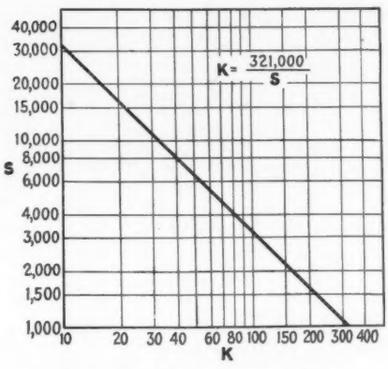


Fig. 2—The constant K in the horsepower formula can be obtained from this curve

Fig. 1, was constructed. Given the speed of the shaft and the horsepower to be transmitted, it offers a ready answer to the diameter of shaft that should be used for the selected allowable stress or, given any three of these four factors, it solves for the unknown quantity.

The formula upon which the chart is based was derived from the equation for twisting moment, as follows:

$$Pr = \frac{\pi d^3 S}{16} \qquad (1)$$

Where P is the force in lb. applied at a radius of r in. from the axis, d is the shaft diameter in in., and S is the allowable stress in lb. per sq.in. Then, letting N equal the speed of the shaft in r.p.m., the horsepower transmitted will be:

$$Hp = \frac{2\pi N \times Pr}{33{,}000 \times 12} \qquad (2)$$

Substituting the right-hand side of Equation (1) for Pr in Equation (2) and combining constants, we obtain:

$$Hp = \frac{Sd^3\ N}{321{,}000} \qquad (3)$$

Since, in any one problem, the allowable stress S will be a constant determined by the factor of safety, Equation (3) may be rewritten:

$$Hp = \frac{d^3 N}{K} \qquad (4)$$

$$\text{Where } K = \frac{321{,}000}{S}$$

An example will serve to show how Equation (4), or any transformation of it, can be solved by means of the nomographic chart. Assume that it is desired to determine the horsepower that can be transmitted by a 4-in. cold-rolled shaft (allowable working stress: 8,025 lb. per sq.in.) at 200 r.p.m. First it is necessary to find the value of the constant K for the given stress. This may be done by dividing 321,000 by 8,025, but for most practical purposes it may be taken from the logarithmic graph, Fig. 2. In this case, the value of K is 40. Therefore on the chart, a line is drawn from 40 on the K scale to 4 on the d scale. This line will intersect the line *0-0* at a point p. Then a line is drawn from 200 on the N scale through the point p and extended until it intersects the horsepower scale. In this example the line intersects at 320 hp., and this is the power that can be safely transmitted by the shaft. In the same manner all analogous problems can be solved.

Retainer and Location Snap Locks

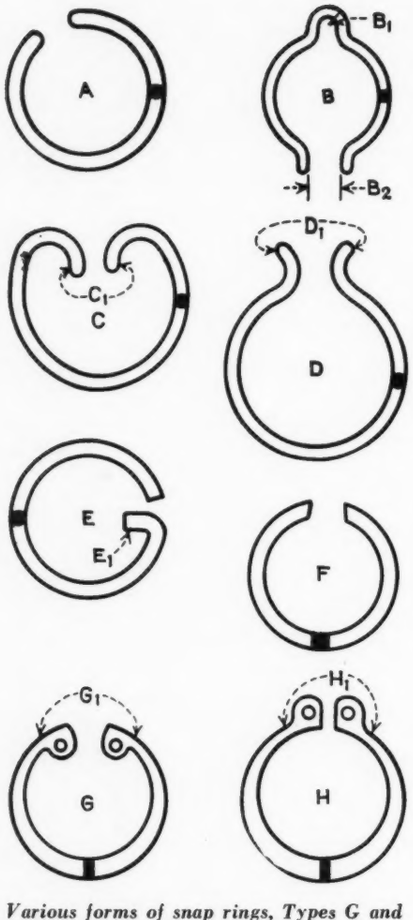
ADAM FREDERICKS
New York, N. Y.

Various forms of wire snap locks are being used more extensively especially where a simple locking device is desirable. Among such applications are the retention of screws, pins, nuts, washers, collars, flanges, glass lenses, small gears, piston wrist pins, and ball and roller bearings. For these parts, the round wire forms, Types *A* to *E* inclusive shown in the accompanying illustration, have usually sufficed.

However, where greater accuracy is required or where the maintenance of a certain location is essential, rectangular wire or pressed steel rings, such as Type *F*, are used. A typical example of the latter type is the use of such snap rings in the outer rings of ball bearings in which a groove is machined to accommodate a ring to provide a shoulder.

Probably one of the most objectionable features of Types *A* to *F* is the inconvenience of disassembling. The retaining groove for Type *A*, when used either internally or externally, must be wide enough for the insertion of several prying tools, used for snapping out the ring. The design of Type *B*, for external use, is better than that of Type *A*, inasmuch as a hook can be used at B_1, but the ring must be expanded enough for the opening B_2 to straddle the diameter of the retaining groove in the shaft.

To remove Types *C* and *D*, for internal and external applications respectively, pliers can be used on the bent wire ends C_1 and D_1 for contracting or expanding the ring. Ring *E*, the formed end E_1



Various forms of snap rings, Types G and H being designed to facilitate disassembly and exert uniform pressure around accommodating groove

of which engages a hole, will be mutilated beyond further use when once disassembled. Because of the type of opening, the ring shown at Type *F* is also very hard to disassemble once it is in place.

Another objection to Types *A* to *F* is that during disassembly all the bending action takes place opposite the opening between the wire ends. This tends to change the shape of the ring so that contact with the groove is not uniform over the entire periphery, thereby making the retainer insecure.

The snap rings shown as Types *G* and *H* are so formed as to overcome the objections of the other types. They are made of hardened and spring-tempered sheet steel. A hole is punched in the lug at each side of the opening for the insertion of a wire or the jaws of a long-nose pliers. This facilitates assembly and disassembly. The inside and outside diameters have different centers, so that the width of metal directly opposite the openings is greater than that at G_1 and H_1 near the lugs. During insertion of the ring, the strain is distributed over the entire circle so that, when in place, the ring exerts uniform pressure all around the accommodating groove. These rings, Types *G* and *H*, are known as "circlips" and are patented in England.

What Hp. Is Required?

To the Editor:

Supplementing the article "What Type of Bearing Is Most Suitable?" on page 67 of February 1937 *Product Engineering*, I would also like to ascertain some method of calculating the horsepower requirements for the illustration as shown on that page. This is somewhat of an unknown quantity as I have found no way to actually calculate the power required.

It is possible, of course, to figure the apparatus as a solid body and use the familiar WR^2 formula as outlined in the article by J. W. Harper in the October 1934 issue of *Product Engineering*, but this seems to give a rather low value as the friction loss in the bearings must be taken into consideration.

In this installation of a carbonator type digester, the drum contains a charge of 25,000 lb., the total revolving load being 42,600 lb., rotating at 1 r.p.m. The drum is driven by a reducing gear motor, a chain drive and a worm wheel. The controlling factor in this problem is the initial and accelerating torque. In this connection, I would like to ask just how much time may be assumed as being required to bring the vessel up to speed, that is, the time *t* required to accelerate from rest as referred to in Mr. Harper's article. Could readers of Product Engineering give me some assistance?—HALE D. SEYMOUR,

Mt. Vernon, Ill.

Drawing Sheet Sizes and Folding Practice

JAMES W. EMMONS
Pearl River, N. Y.

Because of the various sizes of tracings and blue prints used by our firm, considerable difficulty was formerly encountered in filing the tracings and handling the prints in the shop. It was therefore considered desirable to standardize sheet sizes and folding practice.

A study was first made of the standard sizes of tracing and blue-print papers available on the market. After checking the sizes which would be most suitable for our type of work, it was decided to adopt five sizes of paper and four standard methods of folding.

The sizes of sheets selected were of such dimensions as to give a uniform size when folded, as follows: 9 x 13½ in., 13½ x 18 in., 9 x 27 in., 18 x 27 in., and 27 x 36 in. By folding any of these, it can be reduced to 9 x 13½ in., the size of the single sheet. Each of our draftsmen was taught the standard method of folding so that all tracings and prints would be the same size and the portion of the sheet showing the symbol, part number, etc., would be on the front face when folded.

A number of advantages resulted from this standardization. One of the most important, of course, is that each sheet, regardless of its size when open, is of uniform size when folded. Moreover, we find that it is not necessary to carry as many sizes of tracing and blue-print papers in stock as were formerly required.

Can You Work This One?

H. E. SMITH
Newark, N. J.

This Month's Problem—

Railroad Personnel

THERE ARE three railroad executives named Mr. Smith, Mr. Jones and Mr. Robinson. There are also three railroad employees named Smith, Jones and Robinson. Mr. Robinson lives in Philadelphia. Mr. Jones lives in Newark. One of the employees, who is a brakeman, lives as far from Philadelphia as from Newark. Another, who is an engineer, lives halfway between Mr. Jones and the brakeman. The engineer's salary is exactly one-third that of the man living nearest him. The namesake of the brakeman is paid a salary of $8,000 a year. The employee named Smith beats one of the others, who is a fireman, at billiards. What is the engineer's name?

Solution to Last Month's Problem—

Chipmunk on the Log

IN RUNNING from one end to the other of a 10-foot-long log while it is rolling downhill a distance of 50 ft., the chipmunk travels a distance equal to the hypotenuse of a right triangle, 10 ft. on one side and 50 ft. on the other. Therefore, 50.99 ft. is the answer.

News

Textile Machinery Exhibits Reflect Continued Refinements in Design

Most of the machines equipped with anti-friction bearings. Applications of molded plastics, die-castings and electrical devices greatly increased. More attention given to rolled steel welded construction.

ALTHOUGH no radically new mechanical designs of textile machinery featured the Southern Textile Exposition at Greenville, S. C., April 5-9, there was plenty of evidence of design progress during the two years that elapsed since the previous show. New developments included not only changes to make possible higher operating speeds and better operating efficiencies, but also general improvements resulting from the use of new materials and devices and advanced types of construction.

Because they require little lubrication maintenance and virtually eliminate the hazard of oil-spotting the goods being fabricated, anti-friction bearings are being used on practically all machines. The low friction associated with these bearings is a factor of relatively minor importance, according to the chief engineer of one loom manufacturer, who also pointed out that the ball and roller bearings permit greater shaft misalignment, as might occur with the machine operating on a shaky floor.

In line with the greater machining accuracy required for the mounting of ball and roller bearings, there has been a steady trend to more machined surfaces and interchangeable assembly. As compared to a 1928 model, one of the looms exhibited required 40 per cent more machining operations in the manufacture of its parts, including three times as many reaming operations and four times as many grinding operations as on the older model. The new model involved an average of about seven and one-half machining operations per part; the older model only five operations per part.

Machines are being made heavier, necessitated by the sturdier construction required because of the increased speeds. Specific figures were given by Albert Palmer of the Crompton & Knowles Loom Works in his recent paper presented before the American Society of Metals. A comparison showed a 12 per cent increase in total weight as compared to a machine eight years old. Of significance is the fact that the latest models contain 9 per cent less total weight of cast iron, the ratio of steel to cast iron having increased from 0.22 to 0.55 during the past eight years.

Numerous parts formerly made of wood are now molded plastics. These include driving rolls, roll centers, and bobbin centers. Some spinning frame and roving frame rolls are now covered with synthetic rubber compositions. A reason put forward by one engineer for the use of small molded plastic rolls on roving frames was that they do not build up a charge of static electricity in the thread. Another textile machinery designer stated that they were looking for molded plastic compositions possessing greater impact strength in order that they might increase the use of this material.

An increasing number of textile machinery parts are now being die-cast in zinc or aluminum. Bearing housings, bearing caps, parts of stop motion mechanisms, and numerous miscellaneous pieces are now being die-cast. Die costs tend to limit the adoption of die-castings. By standardization of unit parts so that they can be used on a number of machines or models, the designers make possible sufficient quantity production to justify die costs and thus use die-castings.

Electric control is now being demanded more generally with the result that electrical stop motions are rapidly replacing mechanical devices for that purpose. In most of the electrically controlled stop motions electrical contacts cause a solenoid to throw a mechanical linkage into engagement, the machine drive then furnishing the power that operates the mechanical linkage which disengages the clutch and applies the brake. In some machines, however, the control and stopping is done entirely electrically. A yarding machine on exhibit had a motor with built-in magnetic brake to secure instant stopping. An automatic rotary shear for shaving the cloth surface has an automatic control that reverses the rotary shear while a seam is passing through and then reverses the rotation.

The outstanding advantage in the use of electrical stops as compared to mechanical stops is the elimination of linkages. The electrical device can be

One of the three floors of exhibits at the Textile Machinery Show at Greenville, South Carolina

put any place, requiring only wires to the solenoid and power supply.

Because it is easier to align them, many of the motors are now flange mounted. This also makes a more compact arrangement in many applications.

Chromium plating is finding miscellaneous applications including feelers and fingers in contact with the moving thread. The hard chromium prevents rapid wear. Cadmium plating is used extensively on numerous small parts.

Along with the greater use of steel, there is a greater use of welded construction. Longitudinal members on looms are more economically made of rolled steel with the ends welded on, rather than using cast iron which would require a different pattern for each length. Many of the gear and chain guards, drive housings and control boxes are welded sheet steel.

New Test Laboratory for Timken Bearings

Main test room of the new Timken research laboratory

TO EXPAND its research and testing facilities, the Timken Roller Bearing Company has added new quarters and more equipment to its laboratories at Canton, Ohio. The accompanying illustration shows a general view of the main room of the new laboratory which is housed in a single story brick building.

Included in the laboratory equipment is a battery of eight machines for testing bearings up to 8 in. outside diameter to destruction under radial and thrust loads. Another machine tests automobile rear axles and transmissions, together with the bearings that are used in them, the power transmitted being measured by a General Electric dynamometer together with two General Electric hydraulic dynamometers.

To meet their special needs the Timken engineers designed a special bearing testing machine which is thought to be the largest in the world. In it single or double row bearings up to 24 in. outside diameter can be tested to fatigue under radial loads up to 500,000 lb. and thrust loads up to 200,000 lb. A 75-hp., 2-speed motor drives the bearings through a transmission capable of speed changes from 27 to 1,000 r.p.m. A torque device between the transmission and the test spindle indicates the power loss in driving the bearings.

Automotive rear axles are tested for deflection and another machine measures the deflections of the carrier, ring gear, pinion and bearing movements. Other test apparatus includes, profilographs, machines for checking the quietness of bearings, axle fatigue test machines and equipment for photo-elastic research. The axle fatigue testing machine is of special design for testing locomotive driving axles. A cantilever loading system is used, the load being applied by springs.

Office, dark room and drafting facilities as well as sufficient machine tool equipment are also included.

Variety of Papers at Detroit Meeting

ACCORDING to the announcement program of papers to be delivered at the Detroit semi-annual meeting of the American Society of Mechanical Engineers, design and production will share the limelight almost equally.

The program of papers is as follows:

TUESDAY, MAY 18

9:00 A. M. General Session 1 (Railroad Division)
Keynote Address (1) The Scope and Purpose of the Planned Program. (2) Historical Sketch Contrasting the Practice of Automotive Design and Production with Methods in Older Engineering Fields, both by C. F. Hirshfeld, Chief of Research, The Detroit Edison Co.
Modern Locomotive and Axle Testing Equipment, Tracy V. Buckwalter, Vice-President, W. C. Sanders, General Manager Railway Division, and O. J. Horger, Research Engineer, Timken Roller Bearing Co.
1:30 P. M. Descriptive lecture at Hotel Statler followed by inspection tour of General Motors Research Laboratory.

SIMULTANEOUS SESSIONS

1:30 P. M. Joint Session of Hydraulics and Power Divisions.
The Springwells Station of the Detroit Dept. of Water Supply, W. C. Rudd, Asst. Engr. of Power and B. J. Mullen, Chief Plant Engr., Springwells Station, Dept. of Water Supply, Detroit.
Followed by inspection tour through station.
2:00 P. M. Fuels Session.
The Separation and Removal of Cinder and Fly Ash, Arthur C. Stern, Supt., W.P.A. Project 6010, New York.
Incinerators—Municipal, Industrial, and Domestic, H. F. Hersey, Vice-President and General Manager, C. O. Bartlett & Snow Co.
Industrial Heating and Process Furnaces, E. F. Holser, Asst. Chief Engr., Dow Chemical Co.
2:00 P. M. Machine Shop Practice Session.
The Contribution of Broaching to the Automotive Industry, Sol Einstein, Vice-President & Chief Engineer, and Millard Romaine, M. E., Cincinnati Milling Machine Co.
Industrial Bearing Design as Influenced by Automotive Practice, A. B. Willi, Chief Engineer, Federal-Mogul Corp.
2:00 P. M. Rubber Session.
Rubber Cushioning Devices, C. F. Hirshfeld, Chief of Research, The Detroit Edison Company, and E. H. Piron, Engr., Transit Research Corp.
2:30 P. M. Economics Session
Economic Characteristics of Typical Business Enterprises, Walter Rautenstrauch, Prof. Indust. Engr., Columbia University.
8:00 P. M. General Session 2 (Machine Shop Practice Division).
Chairman—Pres. James H. Herron; Vice-Chairman—Past-Pres. William L. Batt; Topic—Improved Methods of Fabrication.
Recent Developments in the Basic Processes of Fabrication, viz., Casting, Forging, Welding, Machining, Pressing, and Rolling, with Social and Economic Implications, William S. Knudsen, Executive Vice-President, General Motors Corp.
Outstanding Contributions made by the Machine-Tool Builders to the Art of Building Automobiles on Mass-Production Lines, Fred W. Cederleaf, Manager of Machinery Division, Ex-Cello-O Aircraft and Tool Co.

WEDNESDAY, MAY 19

9:00 A. M. General Session 3 (Railroad Division)
Chairman—Pres. James H. Herron; Vice-Chairman—W. H. Winterrowd; Topic—Light-Weight High-Speed Trains.
The Aspects of Automotive Engineering which have been Applicable to Railroading, Ed. G. Budd, Pres., Edward G. Budd Mfg. Co.
The Economics of Power for Light-Weight Trains, Dr. Rupen Eksergian, Edward G. Budd Mfg. Co.

SIMULTANEOUS SESSIONS

1:30 P. M. Materials Handling Session
Descriptive Lectures and Tours to Plymouth Assembly Line or Chevrolet Forge Plant.
2:00 P. M. Welding Session (American Welding Society—Co-sponsor)
Welded Steel in High Speed Railway Service, Everett Chapman, Pres., Lunkenweld, Inc.
Hydromatic Welding of Frames, C. L. Eksergian, Chief Engr., Budd Wheel Co.
2:00 P. M. Condenser Session
The Prevention of Surface Condenser Tube Failures, Robert E. Dillon, Supt. Prod., Edison Elec. Illum. Co. of Boston; George C. Eaton, Head. Mech. Prod. Dept., Edison Elec. Illum. Co. of Boston; and H. Peters, Asst. Prof. of Aeronautical Engrg., Massachusetts Institute of Technology.

The Condensation of Flowing Steam, John I. Yellott, Asst. Prof. M. E., Stevens Institute of Technology; and C. Kenneth Holland, Mech. Engrg. Div., Phoenix Engrg. Corp.

2:00 P. M. Fuels Session

Panel Discussion on Spreader Type Stokers, led by J. F. Barkley, Supervising Engr., Fuel Economy Service, U. S. Bureau of Mines.

2:00 P. M. Relations with Colleges Session

The Automobile Industry and Young Engineers, C. J. Freund, Dean, College of Engineering University of Detroit.

2:00 P. M. Lubrication Session

Apparatus and Test Results on Dry Friction. Various Materials and Comparisons with Other Data, W. E. Campbell, Member Technical Staff, Bell Telephone Co.

Oil Film Thickness at Transition from Semi-fluid to Viscous Lubrication, G. B. Karelitz, Professor M. E., and J. N. Kenyon, Instr. in E. E., Columbia University.

4:00 P. M. Petroleum Session

The Petroleum Industry in Michigan, C. R. Miller, Consulting Engineer, Socony-Vacuum Oil Co., White Star Ohio Division.

8:00 P. M. General Session 4 (Society Automotive Engineers—Co-sponsor)

Chairman—Pres. James E. Herron; Topic—Management and Mass-Production Methods.

Charting the Business Course, John W. Scoville, Chrysler Corp.

The Decentralization of Industry, W. J. Cameron, Ford Motor Co.

THURSDAY, MAY 20

9:00 A. M. General Session 5 (Iron and Steel) Division)

Chairman—Pres. James H. Herron; Vice-Chairman—J. A. Clauss; Topic—Steel and Its Application.

Modern Methods of Production and Quality Control of Sheets for Automobile Fabrication, T. F. Olt, Supervising Metallurgical Engineer, American Rolling Mill Co.

Metallurgical Aspects of Hot and Cold Strip for Deep-Drawing Requirements, J. E. Angle, Asst. Gen. Supt., Sheet and Tin Mills, Chicago Dist., and W. F. McGarrity, Strip Metallurgist, Met. Dept., Pittsburgh Dist., Carnegie-Illinois Steel Corp.

SIMULTANEOUS SESSIONS

2:00 P. M. Iron and Steel Session

Application of Impact Tension Tests, Col. Glen F. Jenks, Ord. Dept., U.S.A., Commanding Officer, Watertown Arsenal.

2:00 P. M. Apprenticeship Session

A Year of the New Apprenticeship in the Detroit Industries, Chester W. Culver, General Manager, Employers' Association of Detroit.

Organization and Growth of the Future Craftsmen of America, F. Lee Barrett, Secretary, Advisory Committee, Future Craftsmen of America.

2:00 P. M. Cutting Metals Research Session

A Study of the Lip Clearance on Twist Drills, by Charles J. Starr, Assoc. Prof. M. E., University of Illinois.

The Grinding of Cemented Carbide Milling Cutters, Hans Ernst, Research Engr., and M. Kronenberg, Cincinnati Milling Machine Co.

Report of Subcommittee on Metal Cutting Data on Reducing Production Costs by More Effective Use of Metal Cutting Tools, R. C. Deale.

2:00 P. M. Power Session

The Pooling of Power Sources in a Large Industrial Center, J. W. Parker, Vice-President and Chief Engineer, and R. E. Greene, Engrg. Div., The Detroit Edison Co.

Analysis and Tests on the Hydraulic Circuits of Surface Condensers, G. H. Van Hengel, Consultant, The Detroit Edison Co.

2:00 P. M. Railroad Session

High-Speed Diesel-Engine Maintenance Practice on the Canadian National Railways, I. I. Sylvester, Special Engr., Canadian National Railways.

New Urban Transportation Equipment and New Steam Railroad Equipment, H. L. Andrews, General Electric Co.

7:00 P. M. General Session 6—Dinner Meeting

Toastmaster—James H. Herron, President; Topic—Summary of Week's Program and Its Implications.

Principal Speaker—Col. Willard T. Chevalier, McGraw-Hill Pub. Co.—The Influence of Mass-Production Methods as Exemplified by Detroit Industry on American Life Today.

Awards: Dr. Alex Dow—Honorary Membership in A.S.M.E.

Followed by Informal Reception and Dance.

FRIDAY, MAY 21

9:00 A. M. Power Session

Operating Experiences in the Steam and Power Department of the South's First Alkali Plant, G. P. Avery, Supt., Power & Steam Dept., Southern Alkali Corp.

Formulas for Stresses in Bolted Flanged Connections, Everett O. Waters, Assoc. Prof. M. E., Yale University, D. B. Rossheim, M. E., Charge Mech. Design and Metal, M. W. Kellogg Co., D. B. Westrom, Engr., Travelers Indemnity Co., and F. S. G. Williams, Dist. Mgr., Taylor Forge & Pipe Works.

9:00 A. M. Railroad Session

Railroad Streamlining, A. I. Lipetz, Chief Cons. Engr., American Locomotive Co.

Lightweight Passenger Train Resistance, by A. I. Lotten, Transp. Engineering Dept., General Electric Co.

Mellon Institute Building to Be Dedicated

VISITORS from all parts of the world will attend the exercises to be held May 5-9, to dedicate the new building of the Mellon Institute in Pittsburgh. The dedication ceremony will be held on the afternoon of May 6, with Dr. Edward R. Weidlein, director of the Institute, presiding. Short discourses will be given by Andrew W. Mellon and Richard K. Mellon, representing the founders, following which there will be addresses by three Nobel prize winners, Dr. Irving Langmuir, chemist, Dr. H. C. Urey, chemical physics, and Dr. W. P. Murphy, medicine. Other prominent speakers who will give addresses at the various sessions include Dr. Benjamin T. Brooks, Dr. Karl T. Compton, Dr. F. C. Whitmore, Dr. G. O. Curme, Dr. F. B. Jewett, Sir Frederick Banting and Dr. W. W. G. Maclachlan.

Designed primarily to be the most advanced scientific workshop that modern architecture and construction could give, the aim was also to create a building with simplicity, beauty and majesty. Both of these aims were achieved, the latter through the adoption of Grecian architecture.

The needs of the Institute made necessary a building of about 6,500,000 cu. ft. The architectural form desired dictated that the building be wide in proportion to its height. To secure this low horizontal appearance and yet provide the desired space, three stories are built below ground level. Most striking of the external features are the colonnades with an impressive flight of steps at the main entrance rising from the street.

Other spacious rooms in the building include the auditorium, library, and museum. The fifth to eighth floors are devoted entirely to laboratories. The small laboratories are entered direct from the corridors; the large laboratories each have an office. Special laboratories include constant-temperature constant-humidity rooms, facilities for nutritional studies, ceramics laboratory, experimental plants for research in evolving chemical manufacturing processes, machine, instrument and glass blowing shops, X-ray and spectroscopic facilities, and complete equipment for physical, chemical and metallurgical testing.

Meetings

AMERICAN FOUNDRYMEN'S ASSOCIATION—*Annual convention and foundry show, Milwaukee Auditorium, Milwaukee, Wis. May 3-7. Arthur J. Tuscany, secretary, 632 Penton Bldg., Cleveland, Ohio.*

SOCIETY OF AUTOMOTIVE ENGINEERS—*Summer meeting, The Greenbrier, White Sulphur Springs, W. Va. May 4-9. John A. C. Warner, secretary, 29 West 39th St., New York, N. Y.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—*Semi-annual meeting, Hotel Statler, Detroit, Mich. May 17-21. C. E. Davies, secretary, 29 West 39th St., New York, N. Y.*

AMERICAN GEAR MANUFACTURERS ASSOCIATION—*21st Annual meeting, Galen Hall Hotel, Wernersville, Pa. May 24-25. J. C. McQuiston, manager-secretary, Penn Lincoln Hotel, Wilkinsburg, Pa.*

AMERICAN SOCIETY FOR TESTING MATERIALS—*Annual meeting, Waldorf-Astoria, New York, N. Y. June 28-July 2. C. L. Warwick, secretary, 260 S. Broad St., Philadelphia, Pa.*

Do You Know That—

ONE MANUFACTURER flame cuts the teeth of gears of 3-in. pitch diameter and greater. He also uses the same method in the manufacture of large sprocket wheels. These gears are run only at relatively low speeds. (49)

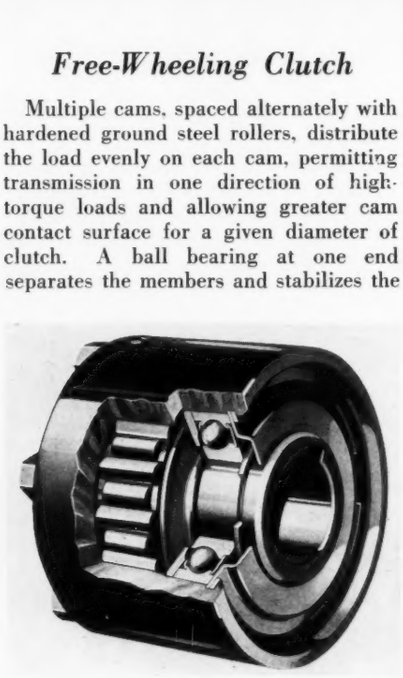
A NEW ELEMENT for electric furnaces is claimed to maintain a constant resistance with and has satisfactorily maintained temperatures higher than 3,000 deg. F. for more than 900 hours in use. (50)

(For details, write the editor, giving the item number.)

New Materials and Parts

Free-Wheeling Clutch

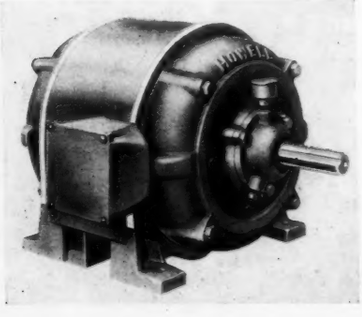
Multiple cams, spaced alternately with hardened ground steel rollers, distribute the load evenly on each cam, permitting transmission in one direction of high-torque loads and allowing greater cam contact surface for a given diameter of clutch. A ball bearing at one end separates the members and stabilizes the



load. Opposite end arranged for attachment of sprocket wheel, ratchet arm, or belt pulley. Designed to assure positive cam action and to eliminate ratchet noise and backlash, and intended for such use as on machine tools, printing presses, blowers, ventilating fans, stokers, and automatic heat-treating furnaces. Morse Chain Co., Ithaca, N. Y.

Splash-Proof Motor

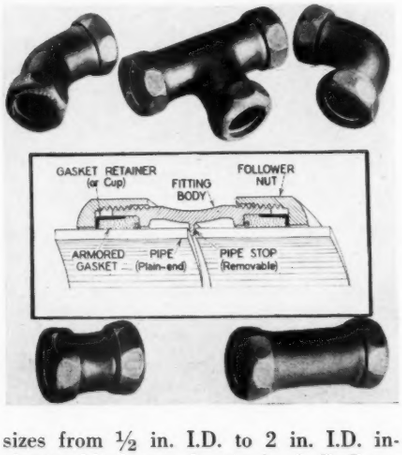
Ventilating air enters and exhausts underneath a steel encircling shell. Air circulates over entire stator core and all coils. Designed for use where liquids splash, hoses play, and frequent washups are required. End plates are totally inclosed, ball bearings are double-sealed,



and terminal box is water-tight. Known as type R, it is available in all standard electrical types from 1 to 75 hp. Howell Electric Motors Co., Howell, Mich.

Flexible Connection for Plain-End Pipe

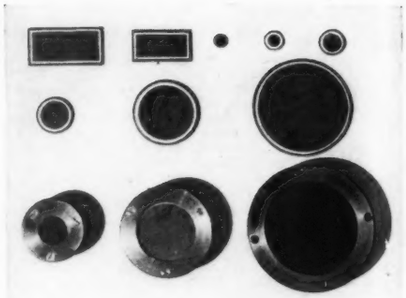
Compression fittings require only a wrench to install. Two threaded follower nuts, when screwed up on the threaded body of a fitting, compress two resilient rubber-compound gaskets, sealing in the contents of the line. Resulting joint is tight, and deflections and in-and-out movements of the pipe are absorbed. Threaded or bevelled, as well as plain-end pipe can be joined. Line includes standard and extra-long couplings, ells (both 45 and 90 deg.) and tees, supplied in standard steel pipe



sizes from ½ in. I.D. to 2 in. I.D. inclusive, black or galvanized. S. R. Dresser Mfg. Co., 727 Fisher Ave., Bradford, Pa.

Stainless, Gas-Tight Rigid Tubing

Made by double-lock spiral-seam method, of stainless steel, with smooth inner wall to promote gas exhaustion and prevent carbonaceous or similar particles from adhering to tubing. Offered in diameters ranging from 2½ to 7 in., and in any length desired, for applications in air conditioning, chemical and metallurgical, and food-industries fields. Ludlum Steel Co., Watervliet, N. Y.



Photoelectric Cells

Line of self-generating, dry-disk photoelectric cells. With a maximum voltage of 0.6 volts and a maximum current output of 480 microamp. per lumen, they are claimed to be considerably more powerful and sensitive than conventional cells of this type. For control applications they can be directly connected to a suitable sensitive relay, no amplification being required. Available in a variety of circular sizes from 3/8 to 2-5/8 in. in diameter and in rectangular shapes ranging up to 1-1/2 x 2 in. Dr. F. Loewenberg, 10 E. 40th St., New York, N. Y.

Double-Tone Drawing Paper

Two invisible patterns, similar to single and double crosshatching, are incorporated in the surface of this drawing paper material. After outlines are completed in usual manner, a special dark-tone developer is applied with a brush to make visible the double-crosshatched pattern in areas where it is desired. Similarly, application of light-tone developer brings out single crosshatched pattern. Besides application to drafting work, material may be used to obtain half-tone effects from line engravings. Available in coarse, medium, and fine patterns having 42, 65, and 80 line-to-the-inch screens respectively. The Craftint Mfg. Co., Cleveland, Ohio.

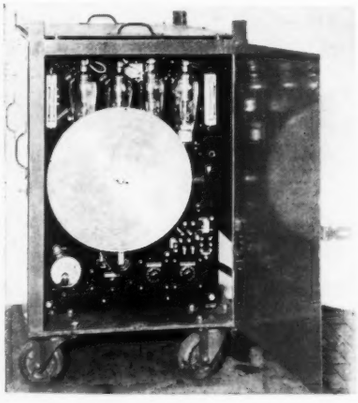
Impact-Resistant Plastics

Line of molding materials which range in impact strength on A.S.T.M. standard test specimen from 0.22 to 2.0 ft.-lb.

energy to break (2.75 to 25 ft.-lb. per sq.in.). Classified as improved impact, medium impact, medium-high impact, and high impact. Two or more molding materials available in each classification, providing in addition to impact resistance such other properties as chemical and water resistance or dielectric strength. Applicable to handset telephones, golf-club heads, football-shoe cleats, instrument cases, junction boxes and other parts requiring relatively high shock resistance. Bakelite Corp., New York, N. Y.

Resistance Seam Welder

Uses ignitron tubes to time power impulses in terms of a definite number of power cycles. Power contactors and transformers are eliminated. The induc-



tive timer consists of a synchronous driven disk rotating once per second, it contains 120 holes, each corresponding to a half cycle of welding current. Steel pins are plugged into the holes according to the timing desired. Suitable for welding heavy gage steels and special metal alloys demanding accurate timing. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Cushion Stuffing Box

Compensates for shaft misalignments, accommodating a total of 20 deg. angularity and from 3/16 to 3/8 in. eccentricity without binding or excessive wear. Unit consists of a metal body in which is mounted a flexible rubber element with a metallic sleeve vulcanized to it. Ten specially treated rings form the combined packing and bearing element and are arranged so that three sets are self-tightening in one direction and two sets in other directions. Beryllium-copper spring provides constant compression. Self-adjusting and self-lubricating. When used strictly as a bearing, unit can be provided with a suitable

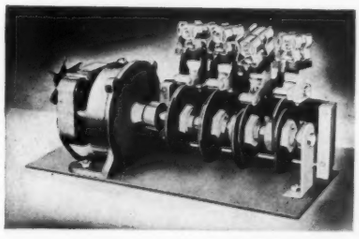
bushing of any required analysis instead of packing element used for stuffing-box applications. Federal-Mogul Corp., Detroit, Mich.

White-Metal Welding Rod

For oxyacetylene welding of die castings, such as grilles, brackets, handles, ornaments, etc. Is claimed to give strength as great as that of base metal, thus eliminating need for reinforcing except where inherent design of part requires an increase of section at joint. Alladin Rod & Flux Mfg. Co., Grand Rapids, Mich.

Time Cycle Controller

Uses metallic mercury switches. Timing sequence and time of circuit operations is adjustable by means of cams. Designed to control machine operations through solenoids. Controller is mounted on a cushion to reduce noise. Cams and terminal panels are made of a plastic molded material. Models are available for operations on 110 or 220 volt circuits, with synchronous or universal



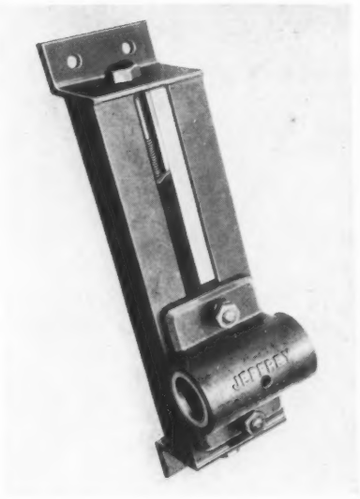
motors, with operating speeds between 1/11 and 60 makes and breaks per minute. Electric Switch Corp., Columbus, Ind.

Spot-Welding Primer

Prevents rusting of lapped edges to be welded and eliminates burning away of paint surrounding the spot weld. Black in color, it air-dries to touch in from 10 to 15 min. and can be handled for welding in from 25 to 30 min. Permits instantaneous spot welding with low voltage and low pressure. Characteristics allow reduction of from 150 to 200 per cent with VMP naphtha. Xylol or toluol can be sprayed on sheet metal afterwards. Designated as X9185 black primer. The Sherwin-Williams Co., Cleveland, Ohio.

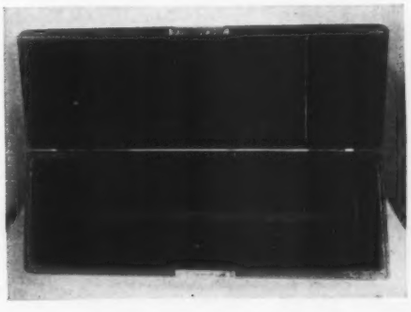
Protected Screw Takeup

Has adjusting screw protected from dust and dirt by an inverted U-shaped shield extending from end to end of the takeup frame. Shield is relieved of any function other than protection of the screw, since sliding base casting, which carries an adjustment nut of bronze, is cored out so that it slides freely over the shield. Adjusting screw does not travel but remains inside the frame and is thus protected from damage at all times. For conveyors, elevators and similar applications. Jeffrey Mfg. Co., Columbus, Ohio.



Ruled Glass Scale

With this transparent scale the rulings can be used in direct contact with the work. Lines and figures are filled by a chemical method resulting in high visibility. The glass blank is 7½ in. long. Three scales are available: two English scales 6 in. long, one ruled in



thirty-secondths of an inch and one ruled in tenths of an inch, and a metric scale 15 cm. long ruled in millimeters. Furnished with a velvet case. Mico Instrument Co., 10 Arrow St., Cambridge, Mass.

Flex-Tip Valves

For air or liquids for use on air guns, on standard water hose, and similar applications, valve opens when synthetic rubber tubing between tip and connection is flexed, thus eliminating handle and providing convenient operation. All working parts encased. No packing glands required. For use with either gases or liquids. Available in forms such as air blow guns, tire chucks, shut-off water valves, and filler faucets. Alemite Corp., Chicago, Ill.

Three-Ply Thermostatic Metal

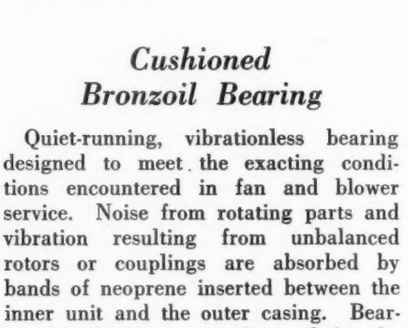
Additional of third element between active and inactive members of thermostatic metal results in smooth operation and uniform movement throughout entire range of from 0 to 1,200 deg. F. For general application in heat-control field. Available in strip form and also in any shape desired. Laminated Metals Corp., Rochester, N. Y.

Auxiliary Cap Seals

Felt closures used to prevent dust and dirt from entering the bearing. Employed in conjunction with regular seals furnished with standard-duty pillow blocks, for unusually dusty and dirty conditions and for certain slow-speed or other bearing applications requiring additional protection. Available in open-end and closed-end types, in full range of sizes to fit standard-duty roller-bearing pillow blocks. Closures other than of felt may be provided for exceptionally dirty or wet conditions. Shafer Bearing Corp., Chicago, Ill.

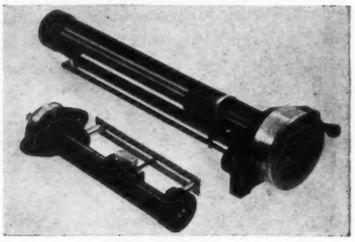
Cushioned Bronzoil Bearing

Quiet-running, vibrationless bearing designed to meet the exacting conditions encountered in fan and blower service. Noise from rotating parts and vibration resulting from unbalanced rotors or couplings are absorbed by bands of neoprene inserted between the inner unit and the outer casing. Bearing is self-oiling, providing oil for the shaft by capillary action from the reservoir contained in the cast-iron inner housing. Oil from the reservoir flows through an absorbent material to a porous bronze liner or bushing which absorbs oil equal to about one-third of its volume.—Dodge Mfg. Corp., Mishawaka, Ind.



Precision Lead Screws

Accurate, when properly mounted and used with a straight corrector bar, to within 0.0005 in. and, with an adjusted corrector bar, to within 0.0002 in. for the overall travel of the nut or for any selected inch of its travel. Screws are made from selected bars of annealed high-carbon steel and threads cut on precision lathe kept at constant temperature. Uniform pitch diameter is substantially free from periodic errors. Available in two sizes providing either 4 or 8 in. of nut travel. Also offered as mounted screw unit, with cradle casting for proper mounting, corrector bar, and graduated drum, ready for installation in test fixture or on machine. Mico Instrument Co., Cambridge, Mass.



Paint Bonding Process

Produces a smoothly etched surface to form a base for paint or enamel chemically developing numerous microscopic crystals integral with the iron or steel to which it is applied. Being insoluable in water, the coating stops moisture which may penetrate the paint film and is said to provide a grip for the paint that will prevent flaking and peeling. Bonding Process Corp., Detroit, Mich.

Wide Range Controller

Non-indicating temperature and pressure controller, Type 2426, housed in a 4½ in. phenol resin molded case. Designed for simplicity in operation and economy in installation. Operates on air pressure of 15 lb. and has a throttling range of from 1 to 15 per cent. Temperature controller has a graduated range of from —30 to 500 deg. F. and the pressure controller has a graduated range of from 15 to 500 lb. Supplied with balanced capillary tubing to overcome room temperature disturbance. American Schaeffer & Budenberg Div., Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

Manufacturers' Publications

"Alemite Controlled Lubrication"—Alemite Div., Stewart-Warner Corp., Chicago, Ill. Catalog, 55 pages, 8½x11 in. Presenting the entire range of Alemite industrial equipment, conveniently classified for quick reference.

Alloy Steels—The Carpenter Steel Co., Reading, Pa. Booklet, spiral bound, 43 pages, 8½x11 in. Following a discussion of alloy steels and the bases for their selection for different types of service the book, entitled "Alloy Steels Simplified," takes up in detail eight types of steels, giving the chemical analysis, workability, physical properties, heat-treatment and uses. Types of steels covered include magnet steels, S.A.E. alloy steels, and special analyses offered by Carpenter.

Ball Bearings—Auburn Ball Bearing Co., 28 Industrial St., Rochester, N. Y. Catalog No. 10, 24 pages, 8½x11 in. Engineering data on many types of ball bearings for various service conditions, including dimensional drawings, tables, specifications and installation diagrams.

Bearings—Johnson Bronze Co., New Castle, Pa. Bulletin 370, 32 pages, 8½x11 in. Lists more than 100 additional general purpose bearings and bushings now available. Arranged numerically and also in progressive sizes with complete price lists. Also includes data on bronze cored and solid bars, hexagon bars, lead-base and tin-base babbitt and graphited bronze bearings.

Belt Conveyor—Acme Steel Co., 2840 Archer Ave., Chicago, Ill. Folder, 8½x11 in. Describing the features and advantages of a new flat-top steel belt conveyor.

Bolts and Nuts—Dardelet Threadlock Corp., 55 Liberty St., New York, N. Y. Bulletin No. 16, 4 pages, 8½x11 in. Describing their self-locking bolts and nuts and the principle of the Dardelet thread.

"Building a Career in Arc Welding"—The Lincoln Electric Co., Cleveland, Ohio. Bulletin No. 416, 10 pages, 8½x11 in. Outlining Lincoln's courses of instruction on arc welding.

Carboloy Grinding Chart—Carboloy Co., Inc., 2981 E. Jefferson Ave., Detroit, Mich. Wall chart, GC-71, 18x12 in. Presents in condensed form the most efficient methods for grinding single-point Carboloy tools, with recommendations on grinding wheels, diamond wheels, diamond lapping disks, wheel speeds, rough and finish grinding procedure, and methods for hogging off stock rapidly.

Circuit Breakers—Square D Co., 6060 Rivard St., Detroit, Mich. Bulletin CA-543A, 20 pages, 8½x11 in. Latest information and price lists on their Multi-breaker, a low-cost circuit breaker for domestic and commercial use.

Controllers—American Schaeffer & Budenberg Div., Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn. Catalog 2400, 8 pages, 7¾x10½ in. Data on their "Wide Range" non-indicating controllers with specifications, temperature and pressure ranges, fittings and applications.

"Copper Alloy Bulletin"—Bridgeport Brass Co., Bridgeport, Conn. Leaflet, 9x12 in. A new bulletin to be issued every month, reporting in brief and convenient form news and technical developments of copper and copper-base alloys.

Diesel Power Unit—Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. Bulletin 3600-A1, 16 pages, 8½x11 in. Describes and illustrates the construction and applications of their Model 36 diesel power units. This model diesel is offered in 2-cylinder sizes and in various combinations, with ratings as low as 10 hp.

Electrodes—Page Steel & Wire Div., American Chain & Cable Co., Inc., Monessen, Pa. Booklet No. DH-984, 15 pages, 8½x11 in. "Hi-Tensile F Electrodes" is the title of this booklet describing a general purpose shielded arc type electrode and the shielded arc method of welding. Drawings, tables and operating instructions for various types of welds are included.

Flow Meters—The Brown Instrument Co., Philadelphia, Pa. Catalog 2004, 56 pages, 8x10½ in. Covers electrical and mechanical indicating, recording and integrating flow meters and their application in power plants, hydro-electric plants, water works and for general industrial service. Also includes recording flow and liquid level controllers.

Graphitic Steels—Steel & Tube Div., The Timken Roller Bearing Co., Canton, Ohio. Folder, 8½x11 in. Describing new alloy steel containing included graphite, particularly adaptable for use in the tool and die industry.

Industrial Noise—General Radio Co., Cambridge, Mass. Folder, 8½x11 in. Data and specifications on type 759-A sound-level meter for measuring the intensity of sound in mechanical equipment and machinery.

Light-Sensitive Cells—General Electric Co., Schenectady, N. Y. Bulletin GEA-2467, 8x10½ in., 16 pages. Technical and descriptive data covering light-sensitive cells, includes definitions, applications and characteristics charts.

Magnetic Relays—Ward Leonard Electric Co., Mount Vernon, N. Y. Bulletin 131, 4 pages, 8x10½ in. Lists more than 100 relays for heavy duty (1 to 25 amp.) on d.c. and a.c. circuits, particularly adapted for transfer purposes.

Motors—Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. Bulletin 1600, 4 pages, 8½x11 in. Describes polyphase wound-rotor or slip-ring ball bearing induction motors which can be operated at either constant or varying speeds.

Pressure Regulator Selector Chart—Davis Regulator Co., 2522 S. Washtenaw Ave., Chicago, Ill. Chart folded to 8½x11 in. For quick and accurate selection of the proper type of pressure reducing valve to use for any given service on steam, gas, air, oil or water.

Recording Instruments—General Electric Co., Schenectady, N. Y. Bulletin GEA-1061F, 32 pages, 8x10½ in. Detailed information and data with numerous tables covering the improvements and advantages of portable and switchboard Type CD strip-chart recording instruments.

Relays for Small Machines—Guardian Electric Mfg. Co., 1629 W. Walnut St., Chicago, Ill. Folder, 8½x11 in. Describes and illustrates contact springs, also stepping, spinning and tilting relays.

Rhodium Floodlighting—Bart Laboratories, Belleville, N. Y. Catalog No. 37, 8½x11 in., 30 pages. Describes construction and types of electroformed rhodium floodlights and reflectors.

"Riveting Aluminum"—Aluminum Company of America, Pittsburgh, Pa. Booklet, 35 pages, 5½x8½ in. Data and information on the methods of riveting aluminum and its alloys.

Rotating Cam Switches—General Electric Co., Schenectady, N. Y. Bulletin GEA-2230, 8 pages, 8x10½ in. Data on the operation and construction of rotating cam switches designed especially for built-in control applications and adaptable to a variety of electrical functions and machine requirements. Includes dimension tables, rating tables and connection diagrams.

Screws, Bolts, Nuts—Pheoll Mfg. Co., 5700 Roosevelt Rd., Chicago, Ill. 1937 Catalog, 108 pages, 5½x8½ in. Latest price lists and illustrations of standard screws, bolts and nuts, conveniently side-cut thumb indexed. A 30-page reference section devoted to technical information includes dimension tables, weight tables and American Standard Screw Thread Specifications.

Silent Chain Drive—Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. Data Book No. 125, 96 pages, 8½x11 in. Covering installations, recommended drive selection, lubrication, drive casings, dimensions of chains and component parts, wheel rims, etc. A section is devoted to price lists of chains and wheels of $\frac{3}{16}$ in. to 2½ in. pitch.

Sheet Metal—Republic Steel Corp., Cleveland, Ohio. Booklet, 20 pages, 8½x11 in. Many uses for sheet metal in a wide variety of applications are pictorially presented in this booklet entitled "The Path

to Sheet Metal Permanence." Also includes information and data on rust resistance, forming and welding properties, physical properties, forms and sizes.

STORY OF NEOPRENE—E. I. duPont de Nemours & Co., Inc., Wilmington, Del. 6 pages, 8½x11 in. A non-technical presentation of the discovery, development and uses of chloroprene rubber, formerly known as "DuPrene."

SPLASH-PROOF MOTORS—Howell Electric Motors Co., Howell, Mich. Bulletin No. 1123, 4 pages, 8½x11 in. Describes new splashproof motor for use in breweries, creameries, laundries and dairies.

SPRING AND SCREW MACHINE PRODUCTS—Peck Spring Co., 14 Summit St., Plainville, Conn. Catalog, 24 pages, 5½x8½ in. Illustrates and covers types, applications, sizes and general specifications of wire springs. A few screw machine products are also shown.

SWITCHES—Bulldog Electric Products Co., Detroit, Mich. 92 pages, 8½x11 in. Covering their line of Vacu-Break switches with illustrations and specifications. Sections devoted to sectionalized unit panel boards, lighting panels and circut breaker products.

TACHOMETERS—James G. Biddle Co., 1211 Arch St., Philadelphia, Pa. Leaflet, Bulletin 1485, 7¾x10½ in. Describing the "Frahm" vibrating-reed tachometer for measuring vibration and speeds up to 30,000 r.p.m.

THERMOMETERS AND HYDROMETERS—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y. Catalog No. 1100A, 16 pages, 8½x11 in. Data on A.S.T.M. thermometers, Tag-A.P.I. and certified hydrometers in addition to their precision and standard types, with comparison scale graduations and conversion tables.

THERMOSTATIC METALS—Laminated Metals Corp., 775 Eddy St., Providence, R. I. Catalog, 12 pages, 8½x11 in. Description, recommended applications and numerous charts for the proper selection of tri-ply, bi-ply, non-corrosive and lagless thermostatic metals.

TIMERS—M. H. Rhodes, Inc., Rockefeller Center, New York, N. Y. Catalog Sheets, 16 pages, Form 37B-1 to 37B-16, 8½x11 in. Descriptions and applications of "Mark-Time" products, including clock-watchers, various timing switches, industrial time controls, coin meters, parking meters, etc.

"TIPS ON CABLE USES"—General Electric Co., Schenectady, N. Y. Folder, GEA-2532, 8x10½ in. Data on 20 types of rubber, cloth, paper and asbestos-insulated cables, one page of the folder being devoted to Versatol rubber-insulated cables.

VALVES—The Foxboro Co., Foxboro, Mass. Bulletin No. 214, 28 pages, 8½x11 in. Reviews throttling and quick-acting open-and-shut type controlled valves and modern controller accessories. Operating characteristics, specifications and dimensions of Stabilflo valves for throttling control are included, together with data for computing valve sizes and rangeability for various fluids and operating conditions.

Books and Bulletins

Punches and Dies

FRANK A. STANLEY. *476 pages, 6 x 9 in. Blue clothboard covers. 671 illustrations, 15 tables. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price, $4.00.*

Since the first edition of this book, printed in 1919, many changes have taken place in press, die and punch design. In this second edition, most of the illustrations of the various types of dies are new; many of the illustrations in the previous edition have been replaced or discarded. Some sections have been completely rewritten and several new chapters are included.

The book is divided into 23 chapters dealing with types and applications of press tools, production of metal blanks, and dies for piercing and blanking. Design principles of combination and compound die construction are covered. Tools for cutting off, shaving, trimming, drawing, bending and forming are well illustrated. Other chapters cover embossing, riveting and swaging, indexing and transfer dies, sub press, punch and die standards, and large dies for automobile work.

The New Vision Locomotive

RAYMOND LOEWY. *108 pages, 7½ x 10 in. Gray clothboard covers. 125 illustrations. Published by The Studio Publications, Inc., 381 Fourth Ave., New York, N. Y. Price $2.50.*

Using pictures as words, the author presents the great advancements made in locomotive appearance and performance. Striking reproductions, with brief explanatory captions, record the progressive advance from the original portable steam engine to the crack streamlined locomotives of today. Locomotives from America, Austria, France, Germany, Great Britain, the Netherlands, Norway, Soviet Russia and the Far East are represented.

This volume is the third in "The New Vision Series." Aircraft was covered in Vol. I, written by Le Corbusier and in Vol. II W. Watson-Baker presented "The World Beneath the Microscope."

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Aircraft Tubing Data

SUMMERILL TUBING CO., *Bridgeport, Montg. Co., Pa. 40 pages, 8½x11 in. Paper covers with a spiral binding. Price $1.00.*

Prepared primarily for aircraft designers, the book presents by means of data sheets, charts and curves the use of seamless steel tubing in aircraft structures. The properties of round, streamline, square and elliptical tubular sections are tabulated. Twenty-four pages are devoted to column strength curves for chrome-molybdenum steel tubes, plotted on the basis of 75,000 lb. per sq. min. yield and 85,000 lb. per sq. in. min. yield strength of the material.

Alignment Charts
Their Construction and Use

PAUL N. LEHOCZKY. *62 pages, 6x9 in. Paper covers. Engineering Experiment Station Circular No. 34. Published by The Ohio State University, Columbus, Ohio. Price 40 cents.*

Written as a practical guide for the actual making and use of alignment charts. The author tells what to do and how to do it, without going into theory and includes only the forms of charts that apply to the simplest and most practical industrial cases.

A chart of logarithmic and arithmetic scales for use in constructing nomographic charts is inclosed with the bulletin. Extra reprints of the chart are available at 10 cents each.

Tin Research

Recent report published by the International Tin Research and Development Council. Copies are available free from L. J. Tavener, 149 Broadway, New York, N. Y.

"Discoloration and Corrosion in Canned Cream" Series A, No. 49, 10 pages.

Condenser Tube Manual

BRIDGEPORT BRASS CO., *Bridgeport, Conn. Heavy grained paper covers, spiral bound. 51 pages, 5½x8½ in.*

Prepared as a reference manual for selecting and specifying condenser, heat exchanger and evaporator tubes. The book also discusses surface condenser design and devotes considerable space to brass and copper piping and copper water tube with solder type fittings.

Photoelasticity

MAX M. FROCHT. *Two bulletins published recently by the Carnegie Institute of Technology, Cambridge, Mass. 6x9 in.*

"The Place of Photoelasticity in Engineering Instruction," reprint of a paper presented at a meeting of the S.P.E.E. at Cornell University. Discusses the general scope of photoelasticity, the essential data it yields and its place in engineering education.

"A Photoelastic Investigation of Shear and Bending Stresses in Centrally Loaded Simple Beams," presented in part at the Fourth International Congress for Applied Mechanics at Cambridge, England. Paper concerns itself with a photoelastic investigation of stresses in beams with special emphasis on vertical and horizontal shears.

PRODUCT ENGINEERING + REFERENCE BOOK SHEET

Electrical Resistors—II

LEO G. HALL

RESISTIVITY VALUES for non-metal materials of commercial purity as shown in the accompanying chart are in ohms per cubic inches. To obtain the resistance of any particular specimen the value from the chart is multiplied by the length of the specimen in inches and then the product is divided by the cross-sectional area of the specimen in square inches. The effect of impurities on the non-metals is generally to lower the resistivity at low temperature more than that at high temperature, so that the curves are flattened somewhat by admixture. Iron oxide has a particularly decided effect in flattening the curves of most of the oxides although it also reduces refractoriness.

Considerable data have been accumulated on the resistivity of various powdered or granular metals. The values for these materials are reported to vary from 100 to 25,000 times those of the same metals in massive form. Since the increased resistivity is that of the contacts between grains, and the latter changes greatly as the grains are sintered together under the influence of heat, the curves are not even approximately reproducible and are valueless.

The curves for granular graphite and kryptol, (a mixture of silicon carbide grains and graphite dust) are closely reproducible at constant pressure. Those given apply to the materials under substantially no pressure. The effect of pressure is both to lower the resistivity and to flatten the curve. The curve for graphite grains was taken from material graded between 10 and 30 mesh.

The contact resistance between graphite blocks has sometimes been used for electric heating. This resistance drops with increased pressure and depends on the character of the surfaces, such as molded or machined surfaces. In one furnace designed by the writer, using machined disks of soft Acheson graphite, the resistance per sq.in. per contact was found to be 0.0054 ohms at room temperature and 0.002 ohms at 3,600 deg.F. under 3 lb. per sq.in. pressure. It was fairly constant after repeated heats, that is, repeated heating did not alter the character of the curve.

There are two types of Nernst filament; one of Zirconia, containing small quanities of yttria and erbium oxide; the other containing small quanities of thoria and ceria. The curve applies to the former. Both must be preheated before conducting well enough to serve as a resistor.

It will be noted that the refractories all become conductors at high temperature. It is therefore necessary in designing a furnace or a heating element to select a refractory that does not conduct appreciably at the designed temperature or to design so that short circuiting through the refractory cannot take place. However, some furnaces have been designed in which wire or some other source of heat is used to heat the furnace to the point where the refractory lining conducts, then shunting the current through the refractory to carry the temperature above the range which the wire will withstand.

Molten salts, and molten glass have also been used to a small extent as resistors for hot baths. The resistivity of molten glass varies by several thousand per cent depending on its composition, which is rarely known. Data are for the most part valueless.

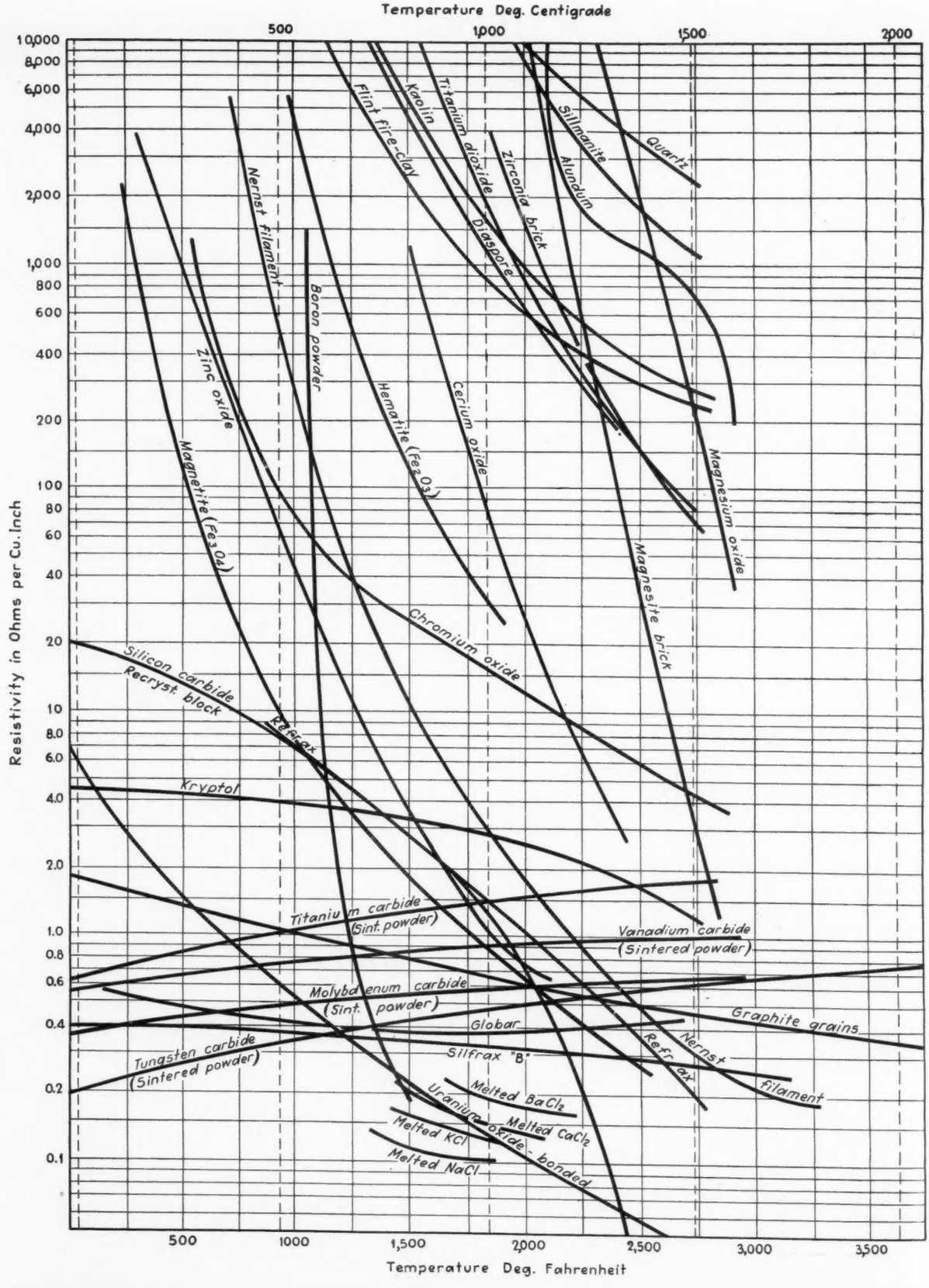
There are also other classes of materials which combine refractoriness with the ability to conduct current at all temperatures desirable in a resistor. Among these are the borides and nitrides. Room-temperature resistivities of a few of these are given below. The complete curves are not available but, because of the other characteristics of these materials, it is extremely probably that the curves closely parallel those of the metallic carbides.

The tremendous drop of resistivity of the non-metals with rise of temperature, together with the fact that few of them conduct well enough when cold to be heated by passage of a current through them, has greatly limited the commercial applications which are suggested by the refractoriness of these materials. However these disabilities can be partially, and in some cases wholly overcome by making use of the fact that impurities cause a decrease of the low temperature resistivity without a proportional decrease at high temperature, thus making the temperature-resistivity curve flatter. The degree of improvement resulting from the introduction of a diluent depends on the character of the diluent, the quantity introduced and the technique used.

Thus by selecting a refractory material of comparatively low cold resistivity and introducing properly selected diluents, resistor materials of fair if not perfect characteristics can be obtained. The introduction of a second diluent sometimes improves the characteristics of a material still further.

Suboxides and other inorganic preparations which are comparatively unstable usually have good resistivity characteristics. Suboxides of many metals can be prepared either by partial reduction of the normal oxide or by sintering or fusing an intimate mixture of the powdered metal and normal oxide together in a neutral atmosphere.

Zirconium boride	0.0000036	ohms per cu.in.
Titanium boride	0.0000060	ohms per cu.in.
Vanadium boride	0.0000063	ohms per cu.in.
Zirconium nitride	0.0000054	ohms per cu.in.
Titanium nitride	0.0000085	ohms per cu.in.
Vanadium nitride	0.0000338	ohms per cu.in.
Tantalum nitride	0.0000053	ohms per cu.in.
Zirconium carbide	0.25	ohms per cu.in.
Chromium carbide	0.63	ohms per cu.in.


Temperature Deg. Centigrade
500
1,000
1,500
2,000
10,000
8,000
6,000
4,000
2,000
1,000
800
600
400
200
100
80
60
40
20
10
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
Resistivity in Ohms per Cu. Inch
Flint fire-clay
Kaolin
Titanium dioxide
Zirconia brick
Diaspore
Sillmanite
Alundum
Quartz
Nernst filament
Boron powder
Zinc oxide
Magnetite (Fe3O4)
Hematite (Fe2O3)
Cerium oxide
Magnesium oxide
Magnesite brick
Chromium oxide
Silicon carbide
Recryst. block
Refrax
Kryptol
Titanium carbide
(Sint. powder)
Vanadium carbide
(Sintered powder)
Molybdenum carbide
(Sint. powder)
Graphite grains
Globar
Nernst
filament
Silfrax "B"
Refrax
Tungsten carbide
(Sintered powder)
Melted BaCl2
Uranium oxide - bonded
Melted CaCl2
Melted KCl
Melted NaCl
500
1000
1,500
2,000
2,500
3,000
3,500
Temperature Deg. Fahrenheit